Cummins Diesels

V6-140 (352)
V8-185 (470) series

V6-155 (378)
V8-210 (504) series

Operation and Maintenance Manual

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Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A.

Operation and Maintenance Manual

Cummins Diesel Engines
V-352 and V-470 series
V-378 and V-504 series

Foreword

This manual is applicable to all V6-140 (V-352), V8-185 (V-470), V6-155 (V-378) and V8-210 (V-504) Series Cummins Diesels currently being produced by Cummins Engine Company, Inc. It contains instructions for operators that will enable them to get the best service from their engines. Before operating engine become familiar with operating procedures as described here-in.

The maintenance section is for men who are responsible for upkeep and availability of engine on the job. The maintenance program is realistic, requires a minimum of control and is profitable to practice.

Repair operations should be performed by specially trained personnel who are available at all Cummins Distributor and Dealer locations.

Full engine and unit repair Shop Manuals may be purchased from a Cummins Distributor at a nominal cost if you are equipped to do your own repair work.

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A., 47201

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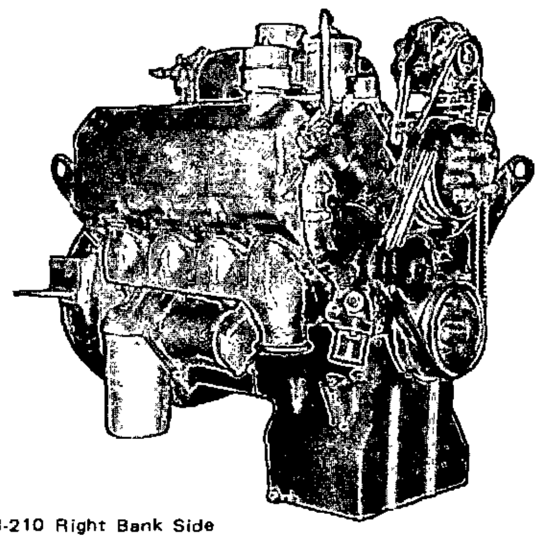
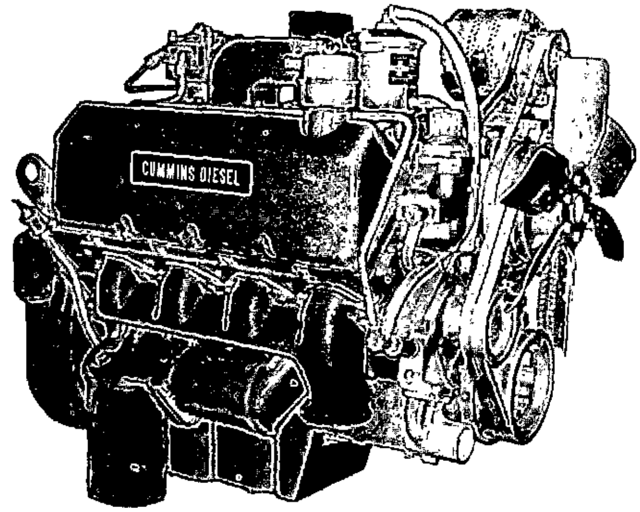


V8-210 Right Bank Side



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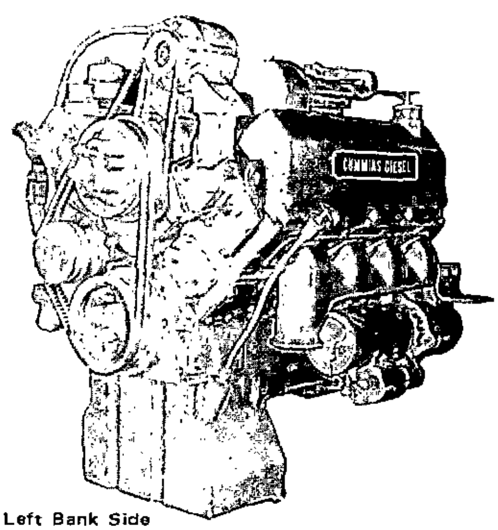
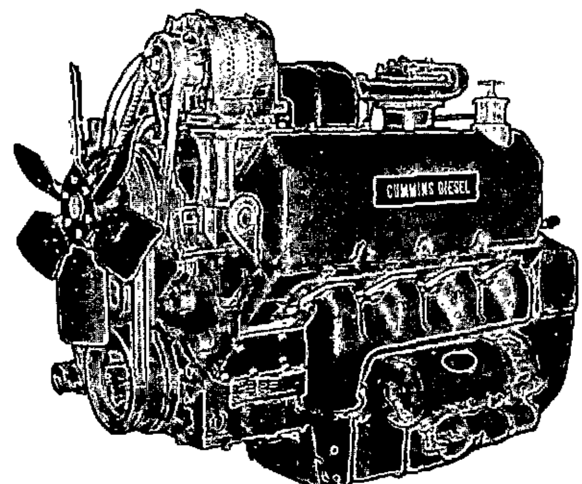


V-504 Left Bank Side

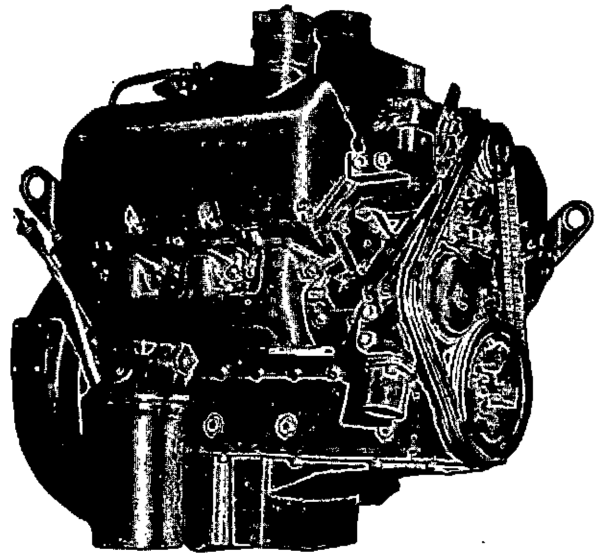


V-470 Left Bank Side

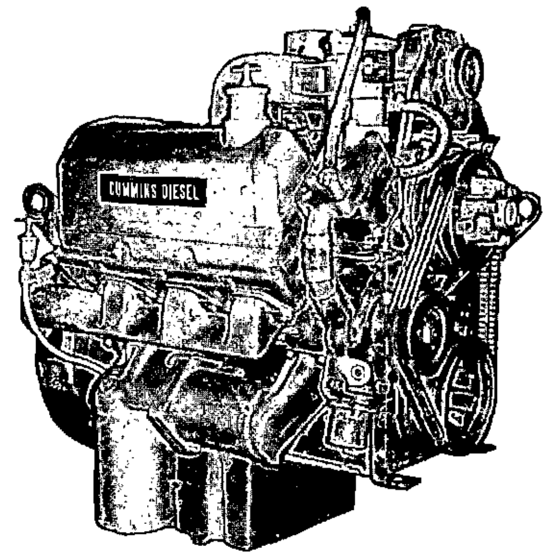
Table 1: Cummins Natural Aspirated V8 Series Engines

Engine Model	Bore and Stroke Inch [mm]	Displacement Cubic Inch [cc]	Valves Cylinder	*Peak Torque @ RPM Ft. Lb. [kg m]	Max. HP @ RPM
V8-185	4 5/8 x 3 1/2 [117.475 x 88.900]	470 [7703.30]	4	329 @ 1900 [45.5057]	185 @ 3300
V-470-C	4 5/8 x 3 1/2 [117.475 x 88.900]	470 [7703.30]	4	325 @ 1800 [44.9525]	185 @ 3300
V8-185-HT (V-470-HT)	4 5/8 x 3 1/2 [117.475 x 88.900]	470 [7703.30]	4	354 @ 1800 [48.9582]	178 @ 3000
V8-185-HT	4 5/8 x 3 1/2 [117.475 x 88.900]	470 [7703.30]	4	354 @ 1800 [48.9582]	185 @ 3300
V8-210 (V-504)	4 5/8 x 3 3/4 [117.475 x 95.250]	504 [8260.56]	4	387 @ 1900 [53.5221]	210 @ 3300

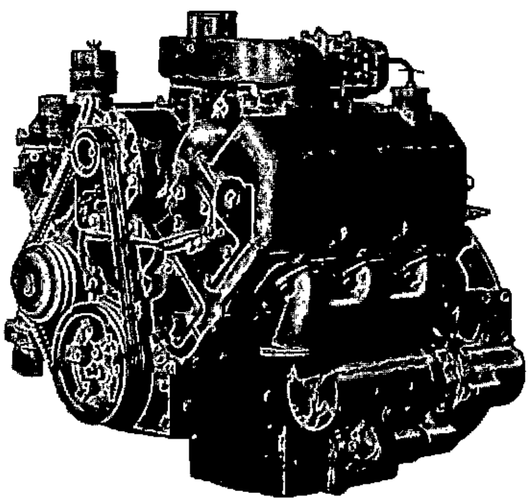
Rating established at 29.92 Inch/Hg. [1.0331 kg/sq cm] barometric pressure (sea level), 60 deg. F [15.6 deg. C] air intake temperature, dry air. Derate engines 3% for each 1000 feet [304.8000 m] above sea level and 1% for each 10 deg. F [5.56 deg. C] rise in air temperature.
*Peak torque within 5%.



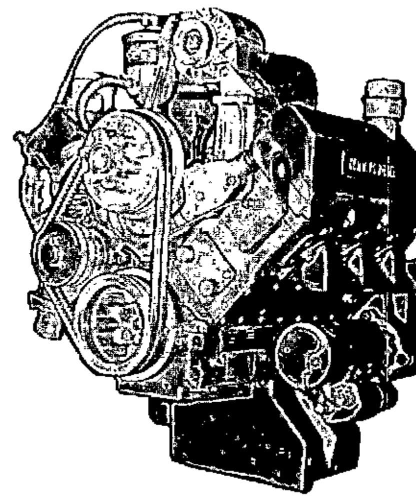
V6-140 Right Bank Side



V6-155 Right Bank Side



V-352 Left Bank Side



V-378 Left Bank Side

Table 2: Cummins Natural Aspirated V6 Series Engines

Engine Model	Bore & Stroke Inch [mm]	Displacement Cubic Inch [cc]	Valves Cylinder	*Peak Torque @ RPM Ft. Lb. [kg m]	Max. HP @ RPM
V6-140	4 5/8 x 3 1/2 [117.475 x 88.900]	352 [5769.28]	4	247 @ 1900 [35.1601]	140 @ 3300
V-352-C	4 5/8 x 3 1/2 [117.475 x 88.900]	352 [5769.28]	4	247 @ 1800 [35.1601]	140 @ 3300
V6-140-HT (V-352-HT)	4 5/8 x 3 1/2 [117.475 x 88.900]	352 [5769.28]	4	264 @ 1800 [36.5112]	134 @ 3000
V6-140-HT	4 5/8 x 3 1/2 [117.475 x 88.900]	352 [5769.28]	4	268 @ 1800 [37.0644]	140 @ 3300
V6-155 (V-378)	4 5/8 x 3 3/4 [117.475 x 95.250]	378 [7195.42]	4	289 @ 1900 [39.9687]	155 @ 3300

Rating established at 29.92 Inch/Hg. [1.0331 kg/sq cm] barometric pressure (sea level), 60 deg. F [15.6 deg. C] air intake temperature, dry air. Derate engines 3% for each 1000 feet [304.8000 m] above sea level and 1% for each 10 deg. F [5.56 deg. C] rise in air temperature.
*Peak torque within 5%.

Operating Principles

The most satisfactory service can be expected from a Cummins Diesel Engine when operation procedures are based upon a clear understanding of engine working principles. Each part of the engine affects operation of other working parts and of the engine as a whole. Cummins Diesel Engines referred to in this manual are four-stroke-cycle, high-speed, full-diesel engines. Horsepower ratings and other engine specifications for each model are tabulated on preceding pages. See Tables 1 and 2.

Cummins Diesel Engine

Cummins Diesel Cycle

Diesel engines differ from other internal combustion engines in a number of ways. Compression ratios are higher than in spark-ignited engines. The charge taken into combustion chamber during the intake stroke consists of air only – with no fuel mixture. Injectors receive low-pressure fuel from the fuel pump and deliver it into individual combustion chambers at the proper time, in equal quantity and atomized condition for burning. Ignition of fuel is caused by heat of compressed air in the combustion chamber.

It is easier to understand function of engine parts if it is known what happens in combustion chamber during each of the four piston strokes of the cycle. The four strokes and the order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly, the valves and injectors must act accordingly to each of the four strokes of the piston. The intake valves, exhaust valves and injectors are camshaft actuated, linked by tappets, push rods, rocker levers and valve crossheads. The camshaft is gear driven by the crankshaft gear thus rotation of the crankshaft directs the action of the camshaft which in turn controls the valves opening and closing sequence and controls the injection timing cycle.

Action of the intake and exhaust valves, and injectors is controlled by properly adjusted linkage (consisting of tappets, push rods, levers and valve crossheads or injector link) connecting them with the engine camshaft. Lobes on the camshaft provide the mechanical action; the camshaft is driven from the crankshaft via a gear train.

Intake Stroke

During intake stroke, piston travels downward; intake valves are open, and exhaust valves are closed. The downward travel of the piston allows air from the atmosphere to enter the cylinder.

The intake charge consists of air only with no fuel mixture.

Compression Stroke

At end of intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed.

At end of compression stroke, air in combustion chamber has been forced by piston to occupy a space about one-seventeenth as great in volume as it occupied at beginning of stroke. Thus, compression ratio is 17:1, or directly in proportion to the amount of air in combustion chamber being compressed.

Compressing air into a small space causes temperature of that air to rise to a point high enough for ignition of fuel.

During last part of compression stroke and early part of power stroke, injectors meter a small charge of fuel into combustion chamber. The fuel charge is atomized as it is forced through small injector cup spray holes.

Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by the existing hot compressed air.

Power Stroke

During the beginning of the power stroke the piston is pushed downward by the burning and expanding gases; both intake and exhaust valves are closed. As more fuel is added and burns, gases get hotter and expand more to further force piston downward and thus adds impetus to crankshaft rotation.

Exhaust Stroke

During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on upstroke.

Upward travel of piston forces burned gases out of combustion chamber through open exhaust valve ports and into the exhaust manifold.

Proper engine operation depends upon two things — first, compression for ignition; and second, that fuel be measured and injected into cylinders in proper quantity at proper time.

Fuel System

The PT fuel system is used on Cummins Diesels. The identifying letters, "PT", are an abbreviation for "pressure-time".

The operation of Cummins PT Fuel System is based on the principle that volume of liquid flow is proportionate to fluid pressure, time allowed to flow and size of passage liquid flows through. To apply this simple principle, the Cummins PT Fuel System provides:

1. A fuel pump to draw fuel from supply tank and deliver it to an individual injector for each cylinder. See Figs. 1-1 and 1-2.
2. Control of fuel pressure being delivered by fuel pump to injectors so individual cylinders will receive proper amount of fuel for power required of engine.
3. Fuel passages of proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure fuel from fuel pump and deliver it into individual combustion chambers at proper time, in equal quantity and proper condition to burn.

Other models of Cummins Diesel Engines were equipped with a PT (type R) fuel pump which has not been adapted to engines described in this manual; however, "type G" designation is retained in this manual for those persons who have previously worked with both types of PT fuel pumps.

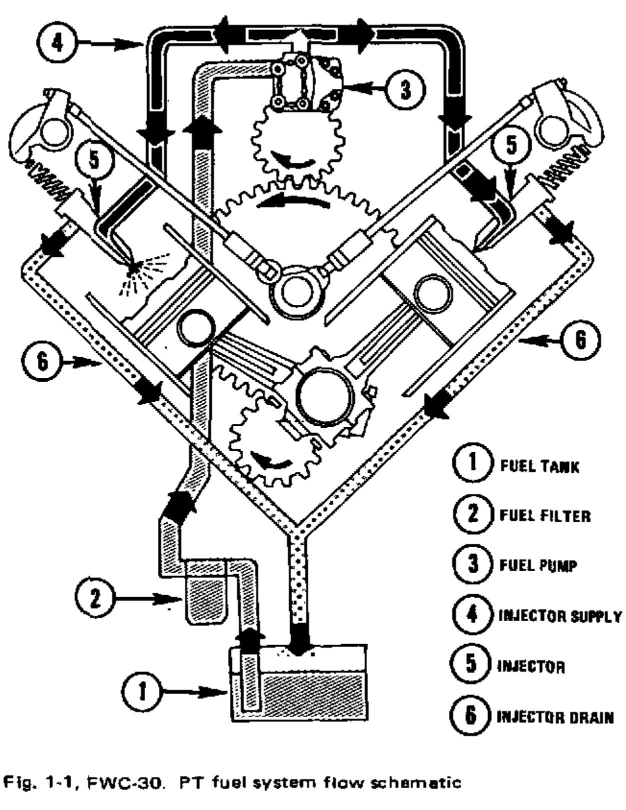


Fig. 1-1, FWC-30. PT fuel system flow schematic

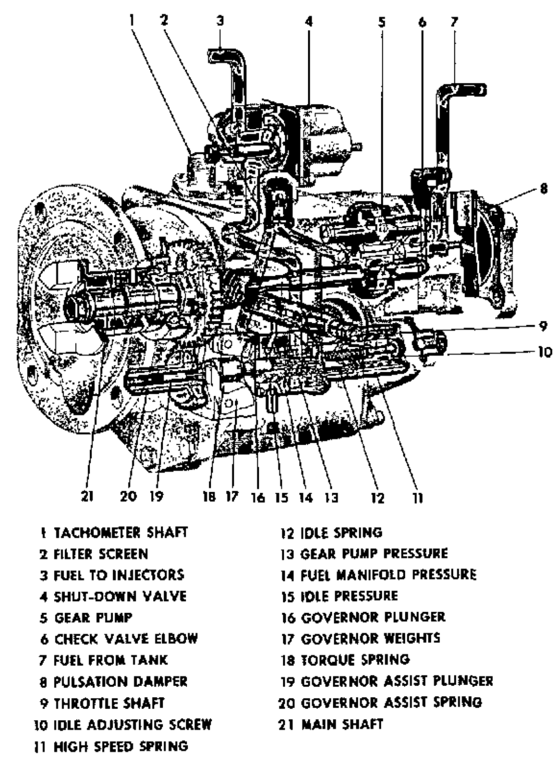


Fig. 1-2, FWC-31. PT (type G) fuel pump cross section/fuel flow

Fuel Pump

The fuel pump is coupled to compressor or fuel pump drive which is driven from engine gear train. Fuel pump main shaft turns at engine crankshaft speed and in turn drives gear pump, governor and tachometer shaft.

The fuel pump assembly is made up of three main units:

1. Gear pump, which draws fuel from supply tank through a fitting on top of fuel pump housing or an inlet fitting in gear pump and forces it through pump filter screen to governor.

2. Governor, which controls flow of fuel from gear pump, as well as maximum and idle engine speeds.

3. Throttle, which provides a manual control of fuel flow to injectors under all conditions in operating range. The location of fuel pump components is indicated in Fig. 1-2.

Gear Pump And Pulsation Damper

Gear pump and pulsation damper are located at rear of fuel pump (rear being end farthest from drive coupling). Fig. 1-2.

Gear pump is driven by pump main shaft and contains a single set of gears to pick up and deliver fuel throughout fuel system. A pulsation damper mounted to gear pump contains a steel diaphragm which absorbs pulsations and smoothes fuel flow through fuel system. From gear pump, fuel flows through filter screen and to governor assembly as shown in Fig. 1-2.

Throttle

Throttle provides a means for operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In PT (type G) fuel pump, fuel flows through governor to throttle shaft. At idle speed, fuel flows through idle port in governor barrel, around throttle shaft sleeve. Above idle speed, fuel flows through main governor barrel port to throttling hole in throttle shaft and onward to injectors.

Governors

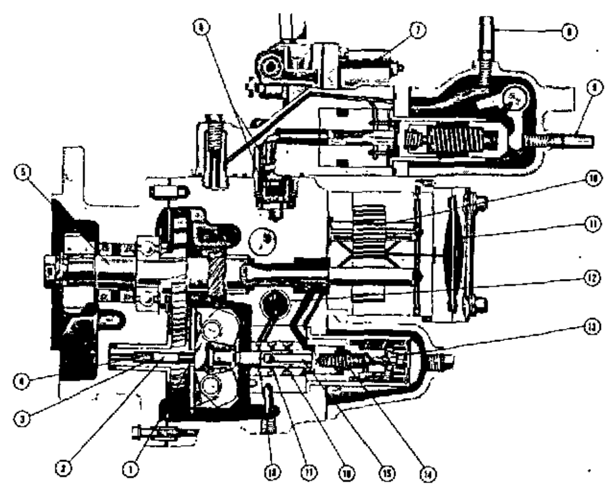
Idling and High-Speed Mechanical Governor: This mechanical governor, often called "automotive governor", is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with throttle control in idle position; second, it cuts off fuel to injectors above maximum rated rpm. The idle springs in governor spring pack position governor plunger so idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through governor to injectors in accordance with engine requirements as controlled by throttle and limited by size of idle spring plunger counterbore on PT (type G) fuel pumps. When engine reaches governed speed, governor weights move governor plunger, and fuel passages to throttle and injectors are shut off. At the same time another passage opens and dumps the fuel into main pump body. In this manner engine speed is controlled and limited by governor regardless of throttle position. Fuel leaving governor flows through throttle, shutdown valve, inlet supply lines into internal drillings in cylinder heads and on to injectors.

PT (type G) Variable-Speed Governors

There are two mechanical variable speed governors used with PT (type G) fuel pump. The "Mechanical Variable Speed (MVS)" governor which is mounted directly on top of, or remotely near, the fuel pump; and "Special Variable Speed (SVS)" governor which is a special spring-pack assembly at lower rear of fuel pump. See Fig's. 1-3 and 1-4.

These governors may be added to existing engines as required; such additions to existing engines will require recalibration of fuel pumps. For all applications in which operator does not control engine speed by maintaining constant touch with throttle, it is recommended M.V.S. governors be used.



(1) GOVERNOR WEIGHTS	(10) GEAR PUMP
(2) GOVERNOR ASSIST	(11) PULSATION DAMPER
(3) SHIMS	(12) THROTTLE SHAFT
(4) GOVERNOR ASSIST SPRING	(13) IDLE ADJUSTING SCREW
(5) MAIN SHAFT	(14) IDLE SPRING
(6) FILTER SCREENS	(15) GOVERNOR PLUNGER
(7) SHUT-DOWN VALVE	(16) GEAR PUMP PRESSURE
(8) MAXIMUM SPEED SCREW	(17) FUEL MANIFOLD PRESSURE
(9) IDLE SPEED SCREW	(18) IDLE PRESSURE

Fig. 1-3, FWC-9. PT (type G) fuel pump with MVS governor

Mechanical Variable Speed (MVS) Governor

This governor supplements "standard or automotive governor" to meet the requirements of machinery on which engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Fig. 1-3.

As a variable-speed governor, this unit is suited to varying speed requirements of cranes, shovels, etc., in which same engine is used for propelling unit and driving a pump or other fixed-speed machine.

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

The (MVS) governor assembly mounts atop fuel pump, and fuel solenoid is mounted to governor housing. See Fig. 1-3. The governor also may be remote mounted.

Fuel from fuel pump body enters variable-speed governor housing and flows to governor barrel and plunger. Fuel flows past plunger to shut-down valve and on into injector according to governor lever position, as determined by operator.

The variable-speed governor cannot produce engine speeds in excess of automotive governor setting. The governor can produce idle speeds below automotive pump idle speed setting, but should not be adjusted below this speed setting when operating as a combination automotive and variable-speed governor.

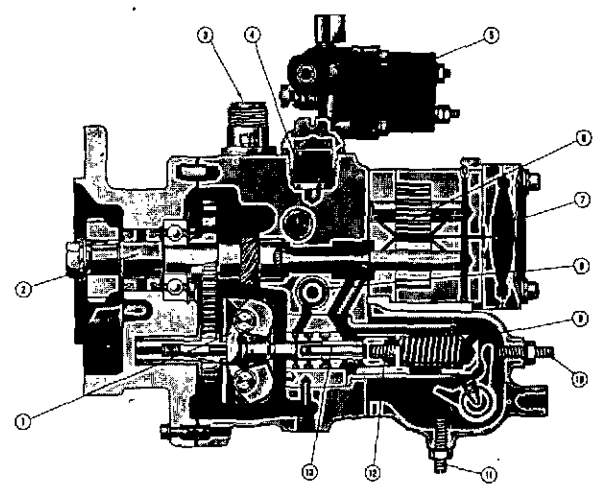
Special Variable-Speed (SVS) Governor

The SVS governor provides many of the same operational features of MVS governor, but is limited in application. An overspeed stop should be used with SVS governors in unattended applications; in attended installations, a positive shutdown throttle arrangement should be used if no other overspeed stop is used. Fig. 1-4.

Marine applications require automotive throttle of fuel pump to be locked open during operation and engine speed control is maintained through SVS governor lever.

Power take-off applications use SVS governor lever to change governed speed of engine from full-rated speed to an intermediate power take-off speed. During operation as an automotive unit, SVS governor is in high-speed position. See operation instructions for further information.

Hydraulic governor applications, not having variable-speed setting provisions, use the SVS governor to bring engine



① GOVERNOR WEIGHTS
② MAIN SHAFT
③ TACHOMETER CONNECTION
④ FILTER SCREEN
⑤ SHUT-DOWN VALVE
⑥ GEAR PUMP
⑦ PULSATION DAMPER
⑧ THROTTLE SHAFT
⑨ GOVERNOR SPRING
⑩ IDLE SPEED ADJUSTING SCREW
⑪ MAXIMUM SPEED ADJUSTING SCREW
⑫ IDLE SPRING
⑬ GOVERNOR PLUNGER

Fig. 1-4, FWC-10. PT (type G) fuel pump with SVS governor

speed down from rated speed for warm-up at or slightly above 1000 rpm.

Hydraulic Governor

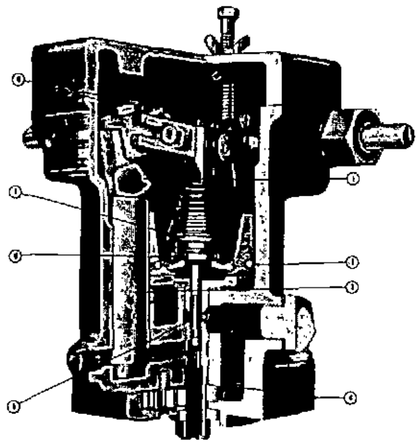
Hydraulic governors are used on stationary power applications where it is desirable to maintain a constant speed with varying loads.

The Woodward SG Hydraulic Governor uses lubricating oil, under pressure, as an energy medium.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in governor control linkage acts to decrease fuel delivery.

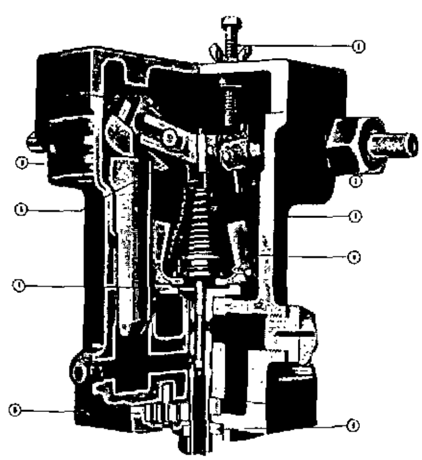
In order that its operation may be stable, speed droop is introduced into governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of approximately one-half of one percent to seven percent.

Assume a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower pilot valve plunger. This will admit oil pressure underneath power piston, which will rise. The movement of power piston is transmitted to terminal shaft by terminal lever. Rotation of terminal shaft through linkage to the fuel



- TERMINAL LEVER
- BALLARM PIN
- SERVO MOTOR PISTON
- GOVERNOR BASE
- PILOT VALVE PLUNGER
- THRUST BEARING
- SPRING SEAT
- SPEED DROP ADJUSTING SCREW

Fig. 1-5, FWC-1. Load off, increased speed, hydraulic governor



- LOW LIMIT ADJUSTING SCREW
- SPEED ADJUSTING SHAFT
- GOVERNOR CASE
- BALL ARM
- DRIVE SHAFT COLLAR
- PUMP GEAR
- BALLHEAD
- FLOATING LEVER
- NAME PLATE

Fig. 1-6, FWC-1. Load on, decreased speed, hydraulic governor

pump causes fuel setting of engine to be increased. Fig's. 1-5 and 1-6.

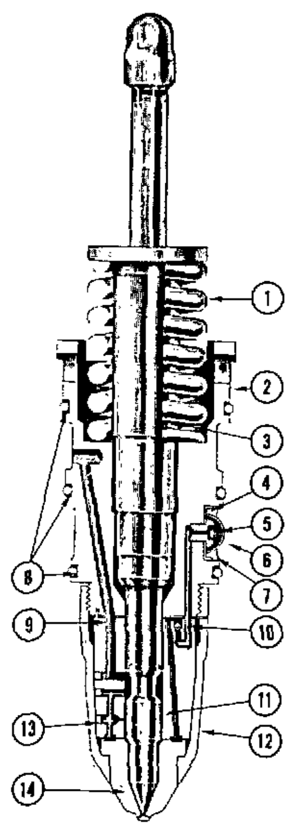
Injectors

The injector provides a means of introducing fuel into each combustion chamber (cylinder). It combines the acts of metering, timing and injection.

Fuel flows from a connection atop fuel pump shut-down valve through a supply line into lower drilled passage in cylinder heads at front of engine. Fig. 1-9. A radial groove around each injector mates with drilled passage in cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in injector body. A fine mesh screen at fuel inlet orifice of each injector provides final fuel filtration.

A second drilling in head is aligned with upper injector radial groove to drain away excess fuel (that not injected into cylinder). A fuel drain at flywheel end of engine allows return of unused fuel to fuel tank.

Fuel grooves around injectors are separated by "O" rings which seal against cylinder head injector bore. Fig. 1-7. This forms a leak-proof passage between injectors and cylinder head injector bore surfaces.



1. SPRING
2. ADAPTER
3. COUPLING
4. GASKET
5. ORIFICE
6. SCREEN
7. CLIP
8. 'O' RING
9. ROLL PIN
10. CHECK BALL
11. PLUNGER
12. BARREL
13. CUP RETAINER
14. CUP

Fig. 1-7, FWC-27. Cross-section PT (type D) injector

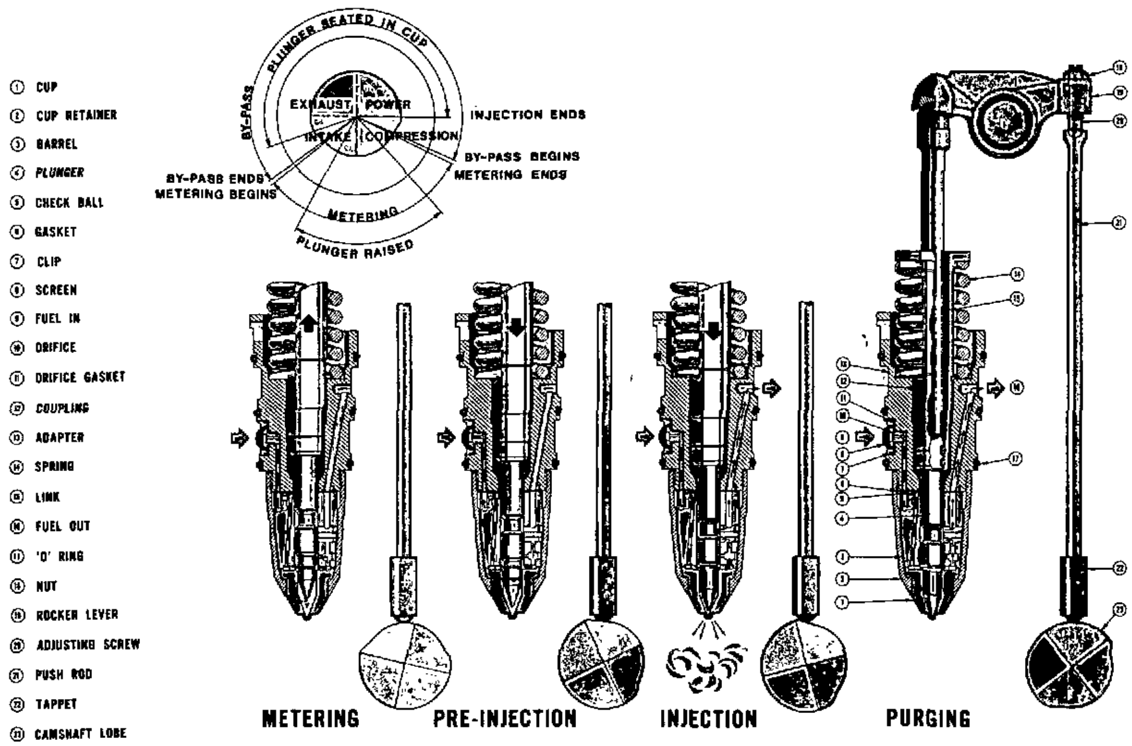


Fig. 1-8, FWC-29. Fuel injection cycle, PT (type D) injector

The PT (type D) (Fig. 1-7 and Fig. 1-8) was developed to improve performance and reduce maintenance costs; use began in 1968 for new engines and they may be adapted to older engines already in service.

The injector contains a ball check valve. As injector plunger moves downward to cover feed openings, an impulse pressure wave seats ball and at the same time traps a positive amount of fuel in injector cup for injection. As the continuing downward plunger movement injects fuel into combustion chamber, it also uncovers drain opening and ball rises from its seat. This allows free flow through injector and drain for cooling purposes. Fig. 1-8.

Fuel Lines And Valves

Supply And Drain Lines

Fuel is supplied through lines to cylinder heads. A common drain line between cylinder heads returns fuel not injected, to supply tank.

Automotive-applied engines are equipped with an external by-pass fuel line from pump damper or gear pump to injector return line or to tank. This reduces internal pump temperatures by returning fuel to tank rather than circulating inside pump when vehicle is going downhill and throttle is in idle position. The check valve in the line is marked and must be installed so arrow points in direction of flow, away from pump.

Shut-Down Valve

Either a manual or electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, control lever must be fully clockwise or open to permit fuel flow through valve.

With electric valve, manual control knob must be fully counterclockwise to permit solenoid to open valve when "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through valve.

Caution: Shut down valve must always be in closed position when engine is not in operation to prevent fuel from entering the cylinders which could cause a hydraulic lock.

Lubricating And Cooling Systems

Lubricating System

Cummins engines are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump located in oil pan of engine.

A pressure regulator is mounted in lubricating oil pump to control lubricating oil pressure.

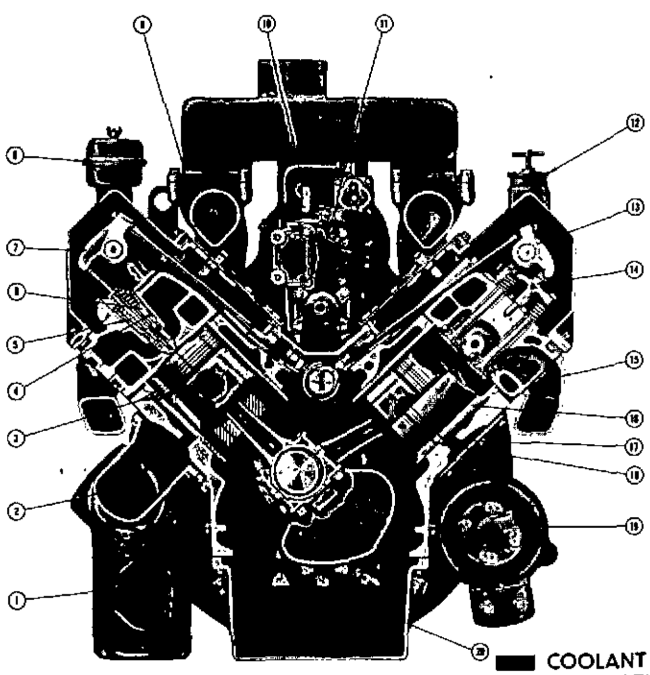
A by-pass valve is provided in full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

1. Oil is drawn into lubricating oil pump through a slotted suction tube.
2. Oil flows to the lubricating pump pressure regulator where pressure is controlled, through a full-flow filter (cooler to full-flow filter, when used) and into drilled passages in the cylinder block.
3. Various drillings throughout the cylinder block, cylinder heads, camshaft, crankshaft, accessory drive, rocker levers and tappets route oil to moving parts of engine. Fig. 1-9.
4. Connecting rod bearings are oiled through drilled passages in crankshaft.

Cooling System

Water is circulated by a centrifugal-type water pump mounted on the front end of the engine and driven by belts from crankshaft.

Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Fig. 1-9. Injector sleeves, in which injectors are mounted, are brass for fast dissipation of heat. A discharge connection between cylinder heads is provided by a water cross-over tube at the rear of the engine. The engine has a thermostat or thermostat(s) to control engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.



1. FULL-FLOW LUBRICATING OIL FILTER
2. OIL COOLER
3. PISTON RINGS
4. FUEL IN
5. FUEL OUT
6. INJECTOR
7. INJECTOR ROCKER LEVER
8. CRANKCASE BREATHER
9. AIR INTAKE MANIFOLD
10. FUEL SUCTION INLET TO PUMP
11. FUEL PUMP
12. OIL FILLER CAP
13. VALVE ROCKER LEVER
14. VALVE CROSSHEAD
15. EXHAUST MANIFOLD
16. CYLINDER LINER
17. CREVICE SEAL
18. PACKING RING
19. CRANKING MOTOR
20. LUBRICATING OIL PUMP

COOLANT
LUBRICATING OIL

Fig. 1-9, LWC-4. Lubricating oil and coolant flow

Air System

The intake air should always be routed through a properly maintained air cleaner to protect the engine from any foreign particles or dirt which are extremely damaging. The air cleaner may be mounted on engine or equipment and may be either oil bath, paper element or composite type depending upon engine application. Air is routed from air cleaner directly to engine intake air manifold crossover.

Air Compressor

The Cummins Air Compressor is a single-cylinder unit driven from engine by integral crankshaft and accessory drive. Lubrication is received from engine lubrication system through internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

Air is drawn into compressor from the engine air system (after air cleaner). As piston moves down, a partial vacuum occurs above it. The difference in cylinder pressure and atmospheric pressure forces inlet valve down from its seat, allowing air to flow through intake port and into cylinder. When piston has reached the bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat. Fig. 1-10.

Compression

When piston starts its upward stroke, the increased pressure of air in cylinder and head forces outlet valve away from its seat. The compressed air then flows through outlet ports and into air tank as piston continues its upward stroke. On piston down-stroke, exhaust valve closes and intake valve opens except during unloading period.

Unloading

When pressure in air tank is at a predetermined level, air pressure is applied to top of unloader cap by a compressor governor. This pressure forces cap down and holds intake valve open during non-pumping cycle to prevent creation of a vacuum above the piston. When pressure in air tank drops, cap returns to its upper position and intake and compression sequences begin once again.

Vacuum Pump

The Cummins Vacuum Pump, shown in Fig. 1-11, is an adaption of Cummins Air Compressor; it is a single-cylinder unit driven from engine by integral crankshaft and accessory drive. Lubrication is received from engine lubricating system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

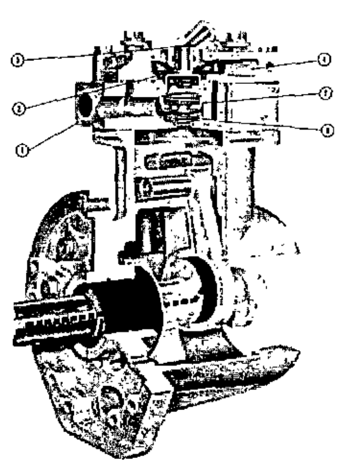


Fig. 1-10, AWC-1. Cummins air compressor

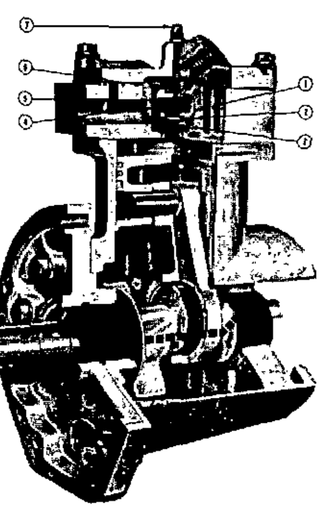


Fig. 1-11, V11205. Cummins vacuum pump

Air Intake

As piston moves downward on intake stroke a vacuum occurs above piston. The difference in cylinder pressure and atmospheric pressure forces inlet valve from its seat allowing air to flow through intake port into cylinder from vacuum tank thus creating vacuum in vacuum tank. When piston has reached bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat. Fig. 1-11.

Compression

When piston starts upward stroke, increased pressure of air in cylinder and head forces outlet valve away from seat. Air then flows through outlet port and is discharged into vacuum pump crankcase or engine crankcase, as piston continues upward stroke. When piston reaches end of stroke, air pressure in head drops to a point where spring forces exhaust valve against seat and closes outlet passage. Fig. 1-11.

Operating Instructions

The engine operator must assume responsibility of engine care while engine is being operated. This is an important job and one that will determine to a large degree the extent of profit from operation. There are comparatively few rules which operator must observe to get best service from the Cummins Diesel. However, if any of these rules are broken, a penalty is certain to follow. The penalty may be lower engine efficiency, or it may be in down time and costly repair bills resulting from premature engine failure.

General—All Applications

New Engine Break-In

Cummins engines are run-in on dynamometers before being shipped from factory and are ready to be put to work in applications such as emergency generator sets. For marine engine operation and maintenance, consult Cummins Bulletin No. 983648. In other applications, engine can be put to work, but operator has an opportunity to establish conditions for optimum service life during initial 100 hours or 3000 mi. [4827.900 km] of service by:

1. Operating as much as possible in half to three-quarter throttle or load range.

2. Avoiding operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of five minutes.

3. Developing the habit of watching engine instruments closely during operation and letting up on throttle if oil temperature reaches 250 deg. F [121.1 deg. C] or coolant temperature exceeds 190 deg. F [87.8 deg. C].

4. Operating with a power requirement that allows acceleration to governed speed when conditions require more power.

5. Checking oil level each 300 mi. [482.790 km] or 10 hours during the break-in period.

Pre-Starting Instructions—First Time

Priming Fuel System

1. Prime fuel pump before starting engine for first time. Remove plug next to tachometer drive and fill with clean fuel oil meeting the specifications outlined on Page 3-1. Fill gear pump through suction fitting with clean lubricating oil to aid in faster pick-up of fuel when inlet fitting is at gear pump. If fuel filter is "dry", fill with clean fuel oil before starting engine.

2. Check fuel tanks. There must be an adequate supply of good grade, clean, No. 2 diesel fuel in tanks. See "Fuel Oil Specifications," Page 3-1.

3. If injector and valve adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting engine. See page 5-21, for injector adjustment.

Priming Lubricating System

1. Fill crankcase to "L" (low) mark on dipstick with oil meeting specifications shown on Page 3-2. No change in oil viscosity or type is needed for new or newly rebuilt engines.

2. Remove pipe plug from lubricating oil filter head (1, Fig. 2-1).

Caution: Pressurize at this plug only to prevent rupturing element.

3. Connect a hand or motor driven priming pump line from source of clean lubricating oil (see Page 3-2) to oil plug boss.

4. Prime until a 30 psi [2.1090 kg/sq cm] minimum pressure is obtained.

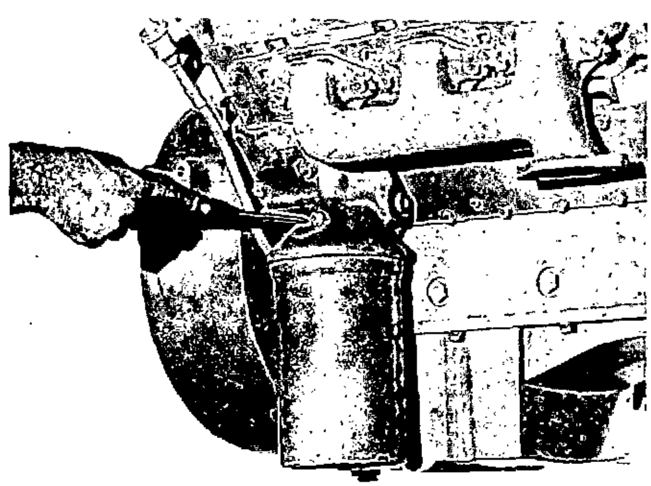


Fig. 2-1, V11466. Lubricating system priming point

5. Crank engine for at least 15 seconds (with ignition switch "off") while maintaining external oil pressure at minimum of 15 psi [1.0545 kg/sq cm].

6. Remove external oil supply and replace plug in oil filter head.

Caution: Clean areas of any lubricating oil spilled while priming engine or filling crankcase.

7. Fill crankcase, through filler tube, to "H" (high) mark on dipstick with oil meeting specifications shown on Page 3-2. No change in oil viscosity or type is needed for new or newly rebuilt engines.

Caution: After engine has run a few minutes, it will be necessary to add lubricating oil to compensate for that absorbed by filter element(s) and oil cooler.

Normal-Daily Checks

Check Oil Level

1. A dipstick oil gauge is located on side of engine. The dipstick supplied with engine has an "H" (high) and "L" (low) level mark to indicate lubricating oil supply. Dipstick must be kept with oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different-type installations and oil pan part numbers.

2. Keep oil level as near high mark as possible.

Caution: Never operate engine with oil level below low-level mark, or above high-level mark.

3. Remove 1/8 in. pipe plug from side of oil pan and check high oil level with high level marking on dipstick. This is important if the original dipstick has been replaced.

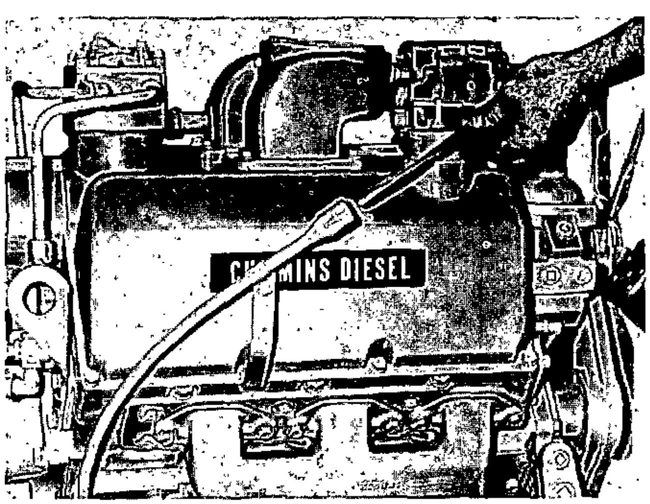


Fig. 2-2, V10715. Checking engine oil level

Check Air Connections

Check air connections to compressor and air equipment, if used, and to air cleaners.

Check Engine Coolant Supply

1. Remove radiator or heat exchanger cap and check engine coolant supply. Add coolant as needed to fill system to operating level.

2. Make visual check for leaks.

3. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 3-4.

Check Fuel Supply And Connections

1. Fill fuel tanks with fuel meeting specifications on Page 3-1.

2. Visually check for evidence of external fuel leakage at fuel connections.

Caution: Fuel leaks may create a fire hazard if not corrected.

3. Tighten fuel fittings as necessary.

Starting The Engine

Starting requires only that clean air and fuel be supplied to combustion chamber in proper quantities while cranking the engine.

Normal Starting Procedure

If fuel system is equipped with overspeed stop, push "Reset" button before attempting to start engine.

1. Set throttle for idle speed.

2. Disengage driven unit or make sure main disconnect switch is open.

3. Open manual fuel shut-down valve, if engine is so equipped. Electric shut-down valves operate automatically.

4. Press starter button or turn switch-key to "start" position.

Note: A manual over-ride knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, open by turning fully clockwise.

Caution: To prevent permanent cranking motor damage, do not crank engine for more than 30 seconds continuously. If engine does not fire within first 30 seconds, wait one to two minutes before recranking.

Cold Starting Aids

To aid in starting engine when temperature is 50 deg. F [10.0 deg. C] or below, starting aids are available as optional equipment.

Direct Application Of Starting Fluid

1. Spray ether starting fluid into air cleaner intake while a second man cranks engine. Fig. 2-3.

Caution: Always start cranking engine before applying ether. Use of too much fluid will cause excessively high pressure and detonation. Never use with preheater systems.

2. Ether fumes will be drawn into intake manifolds and a cold engine should start without difficulty.

Caution: Do not store ether in vehicle cab.

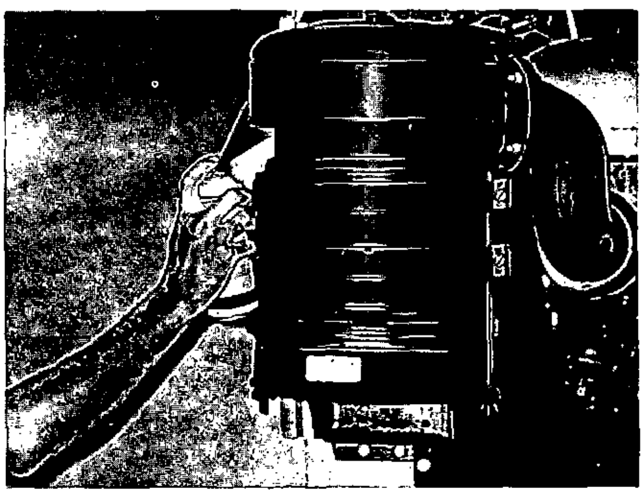


Fig. 2-3, V11468. Ether spray application

Spray Nozzle Application Of Starting Fluid

Spray nozzle application is an effective aid in starting engine when temperatures drop below 50 deg. F [10.0 deg. C]. This cold-starting fluid should never be used with any type preheater system. Serious damage could result.

Spray nozzle assembly consists of a control knob operated from cab, a flexible cable and cable housing attached to container, bracket mounted on fire-wall (1, Fig. 2-4). Pulling knob, in cab, releases spray through a small plastic hose (2) into spray nozzle (3) located in intake crossover connection. Small orifice holes in spray nozzle must be positioned to allow fluid to spray into both left-bank and right-bank intake manifolds.

Caution: When pulling knob, do not hold knob any longer than 2 seconds at any one time. Serious damage could result from releasing excessive fluid into intake chambers.

If engine does not start after first 2 seconds of spray application, wait 1 or 2 minutes and repeat starting procedure. In extreme cold weather conditions, such as –25 deg. F [-31.5 deg. C], if unit will not start with above instructions, remove starting fluid can and warm to room temperature; check spray nozzle in intake connection to be sure orifice holes are free of foreign material. Install can in bracket and connect spray nozzle and repeat normal starting procedure with use of spray nozzle.

Warm Up Engine Before Applying Load

When a cold engine is started, it takes a while to get lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature.

Avoid seizing pistons in liners and running dry shafts in dry

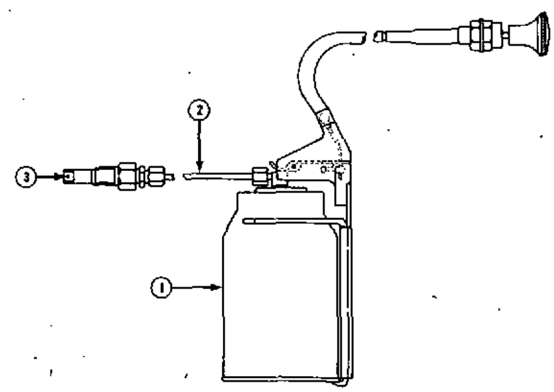


Fig. 2-4, V11469. Starting fluid spray application

bearings by bringing engine up to operating speed gradually as it warms up. Allow engine to run at 800 to 1000 rpm for 4 to 5 minutes or preferably until water temperature reaches 140 deg. F [60 deg. C] before engaging the load. During the next 10 to 15 minutes, or until water temperature reaches 160 deg./165 deg. F [71.1 deg./73.9 deg. C], operate at partial load at approximately 75% of governed rpm.

Engine Speeds

It is necessary in some applications to reduce engine horsepower and rpm due to load or climatic conditions under which engine operates.

Operation of an engine at its maximum rating for prolonged periods will reduce engine life.

Operate At Reduced RPM For Continuous-Duty Or Cruising

When operating engine in a continuous-duty situation and engine is rated at maximum horsepower and rpm such as powering a boat, or running continuous-operation generators, cruising on a level highway, etc., maintain engine rpm at approximately 85 percent of rated rpm. See Table 2-1. This will give adequate power as well as economical fuel consumption.

Engine governors are normally set for reduced rpm or fuel pump set at reduced fuel rate for continuous-duty operation. If engine is applied under these conditions constantly, see later paragraphs.

Table 2-1: Engine Speeds

Model	Governed RPM Full Load	Continuous or Cruising RPM
V6-140	3300	2800 to 2850
V8-185	3300	2800 to 2850
V8E-170	3300	2800 to 2850
V8E-170	3000	2500 to 2550
V-352-C	3000	2500 to 2550
V-470-C	3000	2500 to 2550
V6-155	3300	2800 to 2850
V8-210	3300	2800 to 2850

Idle Speed

In most applications engine idle speeds are 600 to 650 rpm; however, parasitic load may require a slightly higher value to smooth out operation.

Governed Speeds

All Cummins engines are equipped with governors to prevent speeds in excess of maximum or a predetermined lower speed rating.

The governor has two functions: First, it provides exact amount of fuel needed for idling when throttle is in idling position. Second, it overrides throttle and shuts off fuel if engine rpm exceeds maximum rated speed.

Speeds listed in Table 2-1 are for engines rated at maximum rpm and fuel rate.

Many engines, such as generator sets, are set at other values due to equipment being powered or loads applied to equipment and engine.

Instrument Panels

Operate By The Instruments

It makes no difference whether an engine is in a truck, boat or on some other type operation; operator must use the panel board instruments, Fig. 2-5. The instruments indicate whether all systems are functioning properly.

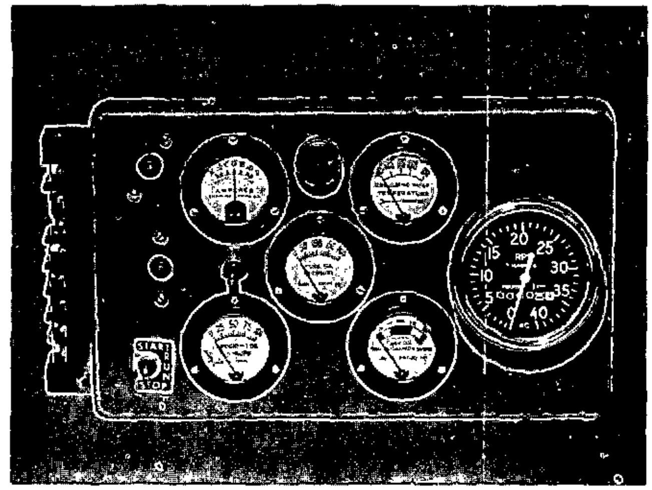


Fig. 2-5, V11501. Instrument panel

Tachometer

Governed engine speed is maximum rpm which a properly adjusted governor will allow engine to turn under full load.

At high idle (no load) condition, engine rpm will exceed governed speed by a small percentage.

Never override governor, or allow engine to exceed governed rating during operation.

Operate at partial throttle in continuous-duty situations to give required torque with tachometer showing rpm approximately 15 percent below governed speed.

Oil Temperature Gauge

The oil temperature gauge normally should read between 180 deg. F [82.2 deg. C] and 225 deg. F [107.18 deg. C] for best lubrication. Under full-load conditions, a temperature of 240 deg. F [115.6 deg. C] for a short period is not to be considered cause for alarm.

Caution: Any sudden increase in oil temperature, which is not caused by load increase, is warning of possible mechanical failure and should be investigated at once.

During warm-up period, apply load gradually until oil temperature reaches 140 deg. F [60 deg. C]. While oil is cold it does not do a good job of lubricating. Continuous operation with oil temperatures much below 140 deg. F [60 deg. C] increases likelihood of crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil pressure or mechanical malfunction in the lubricating oil system. Operator should observe any undue loss of oil pressure immediately and shut down engine before bearing damage can result.

Normal Operating Pressures @ 225 deg. F [107.18 deg. C] Oil Temperature are:

At 650 RPM —— 10/25 psi [0.703/1.7575 kg/sq cm]

At Rated Speed —— 45/75 psi [3.1635/5.2725 kg/sq cm]

Note: Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition.

Water Temperature Gauge

A water temperature of 165 deg. to 195 deg. F [73.9 deg. to 90.6 deg. C] is best assurance that cylinder liners are heated to proper temperature to support good combustion and that working parts of engine have expanded evenly to most favorable oil clearances. See "Engine Warm-Up."

Engine should be warmed up slowly before applying full load so pistons will not expand too fast for cylinder liners. Most cases of piston and liner scoring start as a result of full load on a cold engine.

When water temperature is too low, cylinder walls retard heating of air during compression and delay ignition. This causes incomplete combustion, excessive exhaust smoke and high fuel consumption.

Keep thermostats in engine summer and winter, avoid long periods of idling, and do whatever else is required to keep water temperatures to a minimum of 165 deg. F [73.9 deg. C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

Overheating problems require mechanical correction. It may be caused by loose water pump belts, a clogged cooling system or heat exchanger, or insufficient radiator capacity. Report cases of overheating to maintenance department for correction; 200 deg. F [93.3 deg. C] maximum engine coolant temperature should not be exceeded.

Observe Engine Exhaust

Engine exhaust is a good indicator of engine operation and performance. A smoky exhaust may be due to a poor grade of fuel, dirty air cleaner, overfueling or poor mechanical conditions.

If engine exhaust smoke is excessive, corrective action should be taken.

Maximum Horsepower Requirements

Maximum horsepower is attained only at maximum, or governed, engine rpm. Whenever engine rpm is pulled down by overload, horsepower is lost and continues to be lost as long as the engine continues to lose rpm. When full horsepower is needed, operate the engine near the governor. This rule applies to any kind of application.

Caution: Always operate so power requirements will allow engine to accelerate to, or maintain, governed rpm when operating under loaded conditions.

When more power is required, bring engine speed near governor. This will produce additional horsepower needed.

High-Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.8000 m] of altitude above sea level for a naturally aspirated engine. An engine will have a smoky exhaust at high altitude unless a lower power requirement is used so engine will not demand full-fuel from the fuel system. Smoke wastes fuel, burns valves and exhaust manifolds, and "carbons up" piston rings and injector spray holes.

Engine Shut-Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from combustion chamber, bearings, shafts, etc.

The engine can be shut down completely by turning off switch key on installations equipped with an electric shutdown valve, or by pulling the manual shut-down lever.

Turning off switch key which controls electric shut-down valve always stops engine unless over-ride button on shut-down valve has been locked in open position. If manual over-ride on electric shut-down valve is being used, turn button fully counterclockwise to stop engine. Refer to "Normal Starting Procedure," Page 2-2. Valve cannot be reopened by switch key until after engine comes to complete stop.

Caution: Never leave switch key or over-ride button in valve-open or run position when engine is not running. With overhead tanks this could allow fuel to drain into cylinders causing hydraulic lock.

Idling The Engine

Long periods of idling are not good for an engine because operating temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings.

If engine coolant temperature becomes too low, raw fuel will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If engine is not being used, shut it down. This is particularly important in cold weather when best operating temperatures are difficult to maintain at idle speed.

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to operator before parts fail and ruin engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil *pressure, unusual noises, etc.)* and immediately shut down engine. A delay of ten seconds after a bearing failure causes a knock may result in a ruined crankshaft or allow a block to be ruined by a broken connecting rod.

Never try to make the next trip or another load after engine indicates that something is wrong. It does not pay!

Cold-Weather Protection

1. For cold-weather operation, use of permanent-type ethylene glycol-base antifreeze with rust inhibitor additives is recommended. See Page 3-4.
2. To completely drain cylinder block and cylinder heads open petcock (1, Figs. 2-6 and 2-7) or remove drain plug on water header plate and on lubricating oil cooler, when used. If an air compressor, heat exchanger or other "water-cooled" accessory is used, open petcock on unit. If using a front water crossover, open petcock and drain. Fig. 2-8. Failure to drain any of these units may cause serious damage in freezing weather.

Operator's Daily Report

The engine must be maintained in top mechanical condition if operator is to get most satisfaction from its use. Engine adjustments, etc., are the work of maintenance department. However, the maintenance department needs daily running reports from operator to make necessary adjustments in time allotted and to make provisions for more extensive maintenance work as reports indicate necessity. See "A" Maintenance Checks Page 5-4.

Comparison and intelligent interpretation of daily reports along with practical follow-up action will eliminate practically all operating failures and emergency repairs. Report to maintenance department any of following conditions:

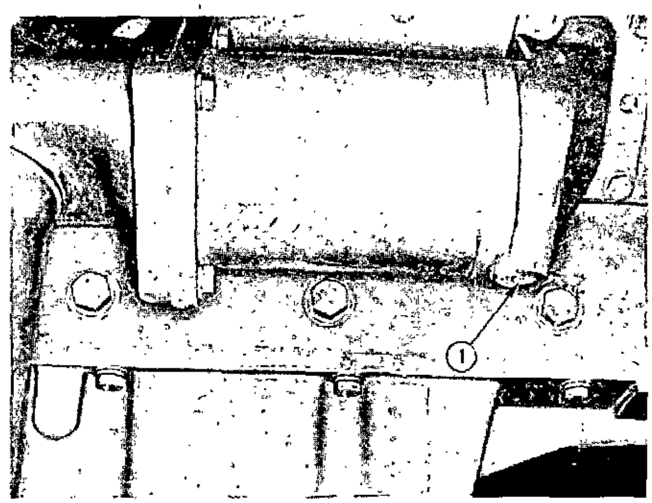


Fig. 2-6, V10819. Coolant drain point (oil cooler side)

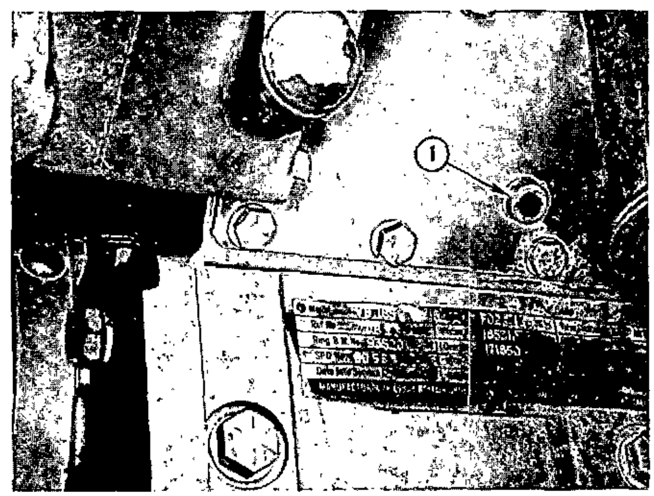


Fig. 2-7, V10820. Coolant drain point (left bank side)

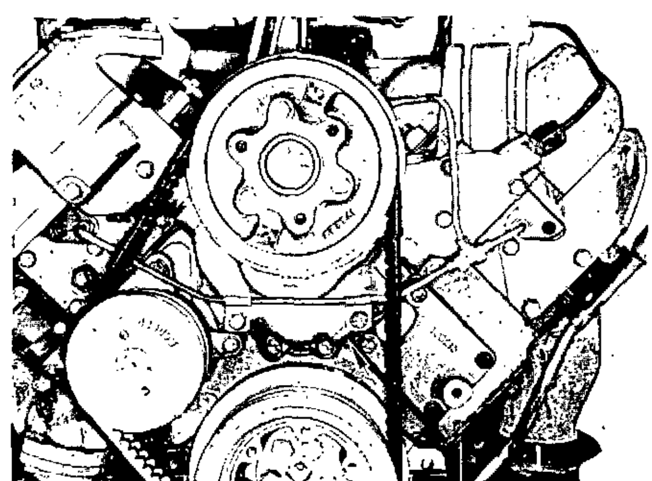


Fig. 2-8, V10821. Coolant drain point (front water crossover)

1. Low, high or change in lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noise.
5. Excessive smoke.
6. Excessive use of coolant, fuel or lubricating oil.
7. Any fuel or lubricating oil leaks.

Automotive Applications

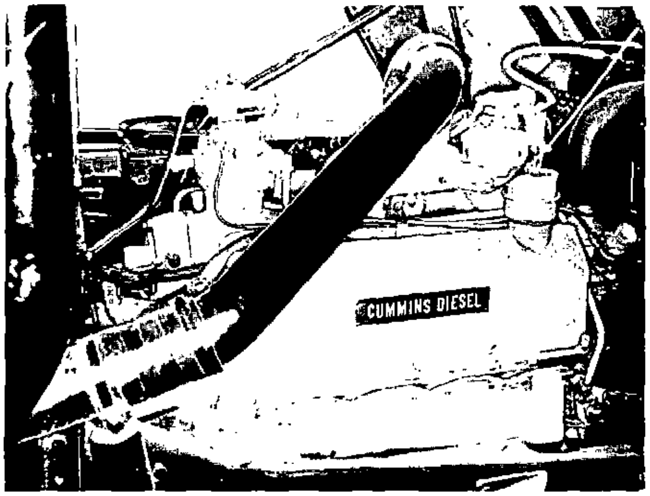


Fig. 2-9, V11604. Typical automotive installation

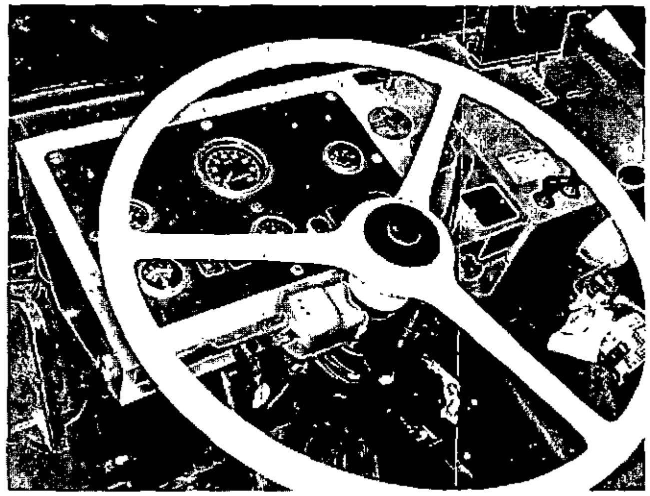


Fig. 2-10, V21962. Typical automotive panel

Apply Load Gradually

Always engage load in a gear low enough to allow acceleration to governed rpm, then catch the next gear as engine decelerates. Do not skip gears.

Shock loads take their toll of tires and transmissions as well as being hard on engine. Apply load gradually.

Operate At Reduced RPM For Cruising

When operating a truck on a level highway, or cruising, hold engine rpm at approximately 85 percent of governed rpm. See Table 2-1. This will give adequate power for cruising and economical fuel mileage.

Most operations will fall in this speed range. The engine will be operating in easy-shift range and will not be working hard.

Many trucks are geared for higher maximum road speeds than schedules require, so drivers can cruise in high gear and at reduced engine rpm. This is good practice as long as engine pulls its load at partial throttle.

Use The Tachometer

Governed engine speed is maximum rpm which a properly adjusted governor will allow engine to turn under full load. Never override governor, or allow engine to exceed governed rating while out of gear, operating at partial load, or driving downhill.

Shift To Lower Gear When Load Pulls Down Engine RPM

If grade gets steeper and load starts to pull down engine rpm, treat that part of grade like another hill and shift to a still lower gear.

Start your down-shift before engine speed drops all the way down to shifting speed to compensate for speed lost during the shift operation. If next gear cannot be "caught" at the shift speed drop, let up on throttle until reaching right rpm for shift. The correct down-shift speed depends upon engine and transmission combination and can be arrived at by judging speed at which the up-shift is best. The practice of shifting gears – next to safety observance – is the most important phase of good engine operation.

When approaching a hill, more torque at the wheels is required. Shift to a lower gear, and "rev up" the engine near the governor. This will give additional horsepower needed without loss of road speed.

Power Take-Off Applications With SVS Governor PT (Type G) Fuel Pump

1. The SVS governor lever is used to change governed speed of engine from automotive rated speed to an intermediate power take-off speed.

2. Engine will not idle if SVS lever is in power take-off speed position and automotive throttle is in idle position. Operate as follows:

a. For PTO operation, bring engine to idle speed.

b. Set automotive throttle 600 to 800 rpm above idle.

c. Hold automotive throttle in above position and shift SVS governor lever to low-speed or power take-off position.

d. Slowly close automotive throttle until speed of power take-off engagement is reached; engage power take-off.

e. Open automotive throttle to full open and control unit with SVS governor lever.

3. To return to automotive throttle control:

a. Use automotive throttle and decrease engine speed until power take-off may be disengaged.

b. Disengage power take-off and shift SVS governor lever to high-speed position.

c. Return automotive throttle to idle position and resume operation of unit as an automotive vehicle.

Caution: Never return automotive throttle to ide position while SVS governor lever is in low-speed or power take-off position or engine will fail to idle properly.

4. SVS governor should not be used with power take-off speeds lower than 1100 rpm; for these applications use MVS governor, described in Section 1, "Operating Principles."

Downhill Operation

The Cummins Diesel is effective as a brake on downhill grades, but care must be exercised not to overspeed engine going downhill. The governor has no control over engine speed when it is being pushed by loaded vehicle. Fig. 2-11.

Never turn off switch key while going downhill. With engine still in gear, fuel pressure will build up against shut-down valve and may prevent it from opening when switch key is turned on.

Use Brake As Needed To Prevent Excessive Engine Speeds

Use a combination of brakes and gears to keep vehicle under control at all times, and to **keep engine speed below rated governed rpm.**

Refer to Tables 1 and 2 on Pages 5 and 6 for most Automotive Engine Specifications.

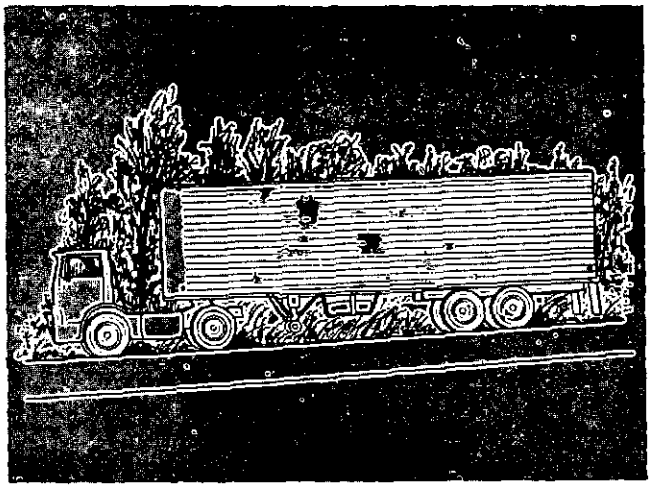
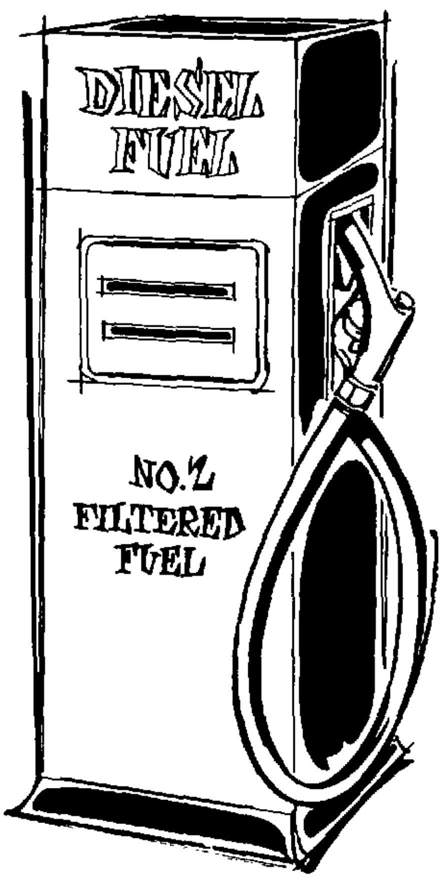


Fig. 2-11, V11605. Downhill operation

Specifications

Providing and maintaining an adequate supply of clean, high-quality fuel, lubricating oil, grease and coolant is one way of insuring long life and satisfactory performance from an engine.

Fuel Oil Specifications



Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	Centistrokes 1.4 to 5.8 @ 100 deg. F. (30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125 deg. for legal temperature if higher than 125 deg. F.
Gravity (ASTM D-287)	30 to 42 deg. A.P.I. at 60 deg. F. (0.815 to 0.875 sp. gr.)
Pour Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122 deg. F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 675 deg. F. All of the fuel should evaporate at less than 725 deg. F.

Lubricating Oil Specifications

The majority of lubricating oils marketed in North America (and many oils marketed world-wide) are designed to meet oil performance specifications which have been established by the U. S. Department of Defense and the Automobile Manufacturers Association. A booklet entitled "Lubricating Oils. For Industrial Engines" listing commercially available brand name lubricants in accordance with their ability to meet these performance specifications is available at a price of $1.25 from Engine Manufacturing Association, 333 North Michigan Avenue, Chicago, Illinois 60601.

Following are brief descriptions of the specifications most commonly used for commercial lubricating oils:

Mil-L-2104B (Commonly called Mil B) is the current U. S. Military specification for lubricating oils for heavy duty gasoline and diesel service. Lubricating oils meeting this specification are designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

Mil-L-45199B (Commonly called Series 3) is the current U. S. Military specification for severe duty lubricating oils to be used in highly rated diesel engines operating with high loads. Lubricating oils which meet this specification have a higher detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation.

Table 1: Cummins Minimum Oil Recommendations

Light Service Stop-and-go	***General-Medium and High Load Factor Service***	
All Models	**Naturally Aspirated**	**Turbocharged Supercharged**
MIL-L-2104B/MS	MIL-L-2104B	MIL-L-2104B/ MIL-L-45199B
Ash Content 1.85% Max.	Ash Content 1.85% Max.	Ash Content 1.85% Max.

Notes:

1. The performance specifications (Table 1) separated by a slash mark indicate that the oil must meet both specifications.

2. MIL-L-2104B/MIL-L-45199B quality oils as used in supercharged and turbocharged engines are satisfactory for use in naturally aspirated engines.

MS This specification was established by the Automobile Manufacturers Association. It requires a sequence of five tests for approval. The primary advantage of lubricating oils in this category is low temperature operation protection against sludge, rust, combustion chamber deposits and bearing corrosion. The test procedure for this specification is published by the American Society for Testing and Materials as STP-315.

Table 2: Operating Temperatures Vs Viscosity

Ambient Temperatures	**Viscosity**
−10 deg F. [−23 deg C] and below	See Table 3
−10 to 30 deg F. [−23 to −1 deg C]	10W
20 to 60 deg F. [−7 to 16 deg C]	20 - 20W
40 deg F. [4 deg C] and above	30

Multigraded lubricating oils can be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limit shown in Table 1.

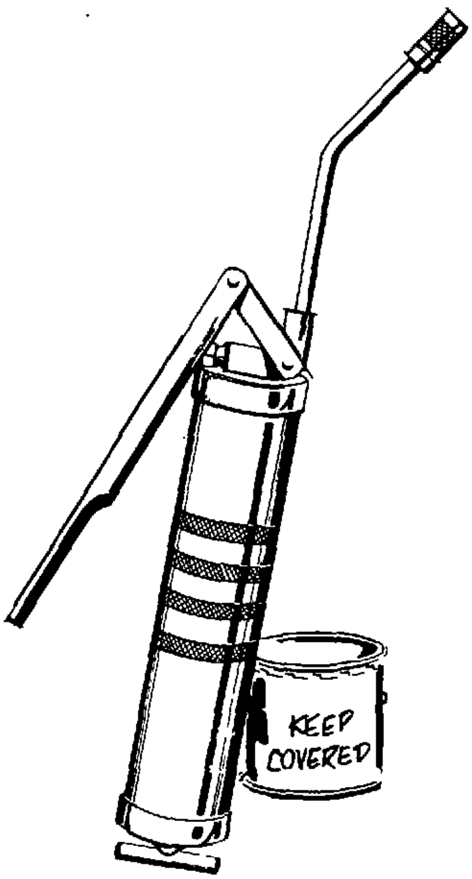
Arctic Operations

For operation in areas where the ambient temperature is consistently below −10 deg. F [−23 deg. C] and there is no provision for keeping engines warm during shutdowns, the lubricating oil should meet the requirements in Table 3.

Table 3: Arctic Oil Recommendations

Parameter (Test Method)	**Specifications**
Performance Quality Level	Mil-L-2104B/MS or Mil-L-2104B/Mil-L-45199B
SAE Viscosity Grade	10W-20, 10W-30, 10W-40
Viscosity @ −30 deg F. (ASTM D-445)	10,000 Centistokes *Maximum*
Pour Point (ASTM D-97)	At least 10 deg F. [6 deg C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum

Water Pump and Fan Hub Lubricants



Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact your lubricant supplier for grease meeting these specifications.

Test	Test Procedure	
High-Temperature Performance		
Dropping point, deg. F.	ASTM D 2265	350 min.
Bearing life, hours at 300 deg F. 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0 deg. F		15,000 max.
Run at 0 deg. F		5,000 max.
Rust Protection and Water Resistance		
Rust test	ASTM D 1743	Pass
Water resistance, %	ASTM D 1264	20 max.
Stability		
Oil separation, %		
30 Hours @ 212 deg F	*FTM 321	5 max.
Penetration		
Worked	ASTM D 217	250-300
Bomb Test, PSI Drop	ASTM D 942	
100 Hours		10 max.
500 Hours		25 max.
Copper, Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

*Federal Test Method Standard No. 791a.

Oil

Fan hubs utilizing tapered roller bearings can be lubricated with SAE 90 Gear Lubricant which meets U.S. Military Specification MIL-L-2105B.

Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow grease to be thrown out, due to rotative speed.

Coolant Specifications

Water should be clean and free of any corrosive chemicals such as chlorides, sulphates and acids. It should be kept slightly alkaline with pH value in range of 8.3 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Install and/or maintain the Cummins Corrosion Resistor on the engine. The resistor by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. In addition, a sacrificial metal plate arrests pitting of metals in the system by electro-chemical action. The resistor is available from any Cummins Distributor or Dealer.

In Summer (No Anti-freeze)

1. Use the corrosion resistor with chromate element(s), Part No. 171645. Do not use element 171646 (PAF) with plain water.

2. Replace corrosion resistor element(s) as recommended in Section 5 of this manual.

3. If no corrosion resistor is used, add 1/2 oz. [14.1747 g] chromate compound in the system for every U.S. gal [3.785 lit] of water or until the coolant mixture meets requirements indicated in Section 5 under "Check Engine Coolant".

In Winter (Using Anti-freeze)

1. Select an anti-freeze known to be satisfactory for use with the chromate element (your Cummins Distributor has been provided a list of compatible anti-freeze) of the corrosion resistor and continue to use the 171645 resistor element or;

2. If you are not sure the anti-freeze is compatible with the chromate resistor element 171645.

a. Use anti-freeze, in percentage to prevent freezing, with a PAF (171646) element in the corrosion resistor.

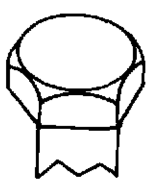
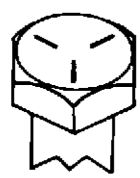
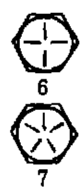
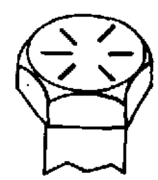
b. Use only anti-freeze, with compounded inhibitors, in proper percentage and follow anti-freeze supplier's recommendation to prevent corrosion.

c. Check corrosion control by draining a sample of coolant from the system as described under "Check Engine Coolant".

d. If there has been a loss of corrosion control, change anti-freeze.

Caution: Never use soluble oil in the cooling system when a Corrosion Resistor is being used.

Standard Capscrew Markings And Torque Specifications

Usage	Much Used	Much Used	Used at Times	Used at Times
Capscrew Diameter and Minimum Tensile Strength psi	To 1/2 – **69,000** To 3/4 – **64,000** To 1 – **55,000**	To 3/4 – **120,000** To 1 – **115,000**	To 5/8 – **140,000** To 3/4 – **133,000**	**150,000**
Quality of Material	**Indeterminate**	**Minimum Commercial**	**Medium Commercial**	**Best Commercial**
SAE Grade Number	**1 or 2**	**5**	**6 or 7**	**8**
Capscrew Head Markings Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).				

Capscrew Body Size (Inches) – (Thread)	Torque Ft-Lb [kg m]	Torque Ft-lb [kg m]	Torque Ft-lb [kg m]	Torque Ft-lb [kg m]
1/4 – 20	5 [0.6915]	8 [1.1064]	10 [1.3830]	12 [1.6596]
– 28	6 [0.8298]	10 [1.3830]		14 [1.9362]
5/16 – 18	11 [1.5213]	17 [2.3511]	19 [2.6277]	24 [3.3192]
– 24	13 [1.7979]	19 [2.6277]		27 [3.7341]
3/8 – 16	18 [2.4894]	31 [4.2873]	34 [4.7022]	44 [6.0852]
– 24	20 [2.7660]	35 [4.8405]		49 [6.7767]
7/16 – 14	28 [3.8132]	49 [6.7767]	55 [7.6065]	70 [9.6810]
– 20	30 [4.1490]	55 [7.6065]		78 [10.7874]
1/2 – 13	39 [5.3937]	75 [10.3725]	85 [11.7555]	105 [14.5215]
– 20	41 [5.6703]	85 [11.7555]		120 [16.5960]
9/16 – 12	51 [7.0533]	110 [15.2130]	120 [16.5960]	155 [21.4365]
– 18	55 [7.6065]	120 [16.5960]		170 [23.5110]
5/8 – 11	83 [11.4789]	150 [20.7450]	167 [23.0961]	210 [29.0430]
– 18	95 [13.1385]	170 [23.5110]		240 [33.1920]
3/4 – 10	105 [14.5215]	270 [37.3410]	280 [38.7240]	375 [51.8625]
– 16	115 [15.9045]	295 [40.7985]		420 [58.0860]
7/8 – 9	160 [22.1280]	395 [54.6285]	440 [60.8520]	605 [83.6715]
– 14	175 [24.2025]	435 [60.1605]		675 [93.3525]
1 – 8	235 [32.5005]	590 [81.5970]	660 [91.2780]	910 [125.8530]
– 14	250 [34.5750]	660 [91.2780]		990 [136.9170]

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

Trouble Shooting

Trouble shooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart on the next page does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column until you come to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done?
3. Has similar trouble occurred before?
4. If the engine still runs, is it safe to continue running it to make further checks?

The answers to these questions can usually be obtained by:

1. Questioning the operator.
2. Reading the Daily Operators Report.
3. Consulting the Maintenance Check Sheet.
4. Taking time to think the problem through.
5. Looking for additional sympthoms.
6. Consulting the Trouble Shooting Chart.
7. Checking the simpliest things first.
8. Double checking all conclusions before "disassembly of the engine or units.

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not be overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

TROUBLE SHOOTING

CUMMINS ENGINES

CAUSES		Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubricating Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM	Restricted Air Intake	●			●	●			●																		
	High Exhaust Back Pressure				●	●			●										●								
	Thin Air in Hot Weather or High Alt.				●	●																					
	Air Leaks Between Cleaner & Engine																				●	●	●				
FUEL SYSTEM	Out of Fuel or Fuel Shut-Off Closed	●										●															
	Poor Quality Fuel	●	●		●	●			●			●												●			
	Air Leaks in Suction Lines	●	●			●					●		●											●			
	Restricted Fuel Lines; Stuck Drain Valve	●	●	●	●	●	●		●	●																	
	External or Internal Fuel Leaks								●							●	●										
	Plugged Injector Spray Holes	●	●	●	●	●			●		●																
	Broken Fuel Pump Drive Shaft	●										●															
	Scored Gear Pump or Worn Gears	●				●																					
	Loose Injector Inlet or Drain Connection	●														●											
	Wrong Injector Cups			●	●	●			●																		
	Cracked Injector Body or Cup								●							●											
	Mutilated Injector Cup "O" Ring								●							●											
	Throttle Linkage					●	●																				
	Incorrectly Assembled Idle Springs									●	●																
	Governor Weights Assembled Incorrectly											●															
	High-Speed Governor Set Too Low					●	●																				
	Water in Fuel	●	●				●					●															
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●											
	Dirty Lube Oil Strainer														●							●	●				
	Faulty Cylinder Oil Control			●	●									●		●					●						
	Clogged Oil Drillings																				●	●	●				
	Oil Suction Line Restriction																●				●	●	●				
	Faulty Oil Pressure Regulator																●										
	Crankcase Low or Out of Oil																●		●	●	●	●	●				
	Wrong Grade Oil for Weather Conditions													●			●										
	Oil Level Too High					●			●					●						●							
COOLING SYSTEM	Insufficient Coolant																●		●	●							
	Worn Water Pump																●		●	●							
	Faulty Thermostats														●		●	●	●	●							
	Damaged Water Hose																●		●	●							
	Loose Fan Belts																●		●	●							
	Radiator Shutters Stuck Open														●			●									
	Clogged Water Passages																●		●	●							
	Internal Water Leaks															●											
	Clogged Oil Cooler																●			●							
	Radiator Core Openings Dirty																●		●	●							
	Air in Cooling System																●		●	●							
	Exterior Water Leaks																●		●	●							
	Insufficient Coolant Capacity																●		●	●							
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●						●	●	○				
	Long Idle Periods	●	●	●	●	●									●	●											
	Engine Overloaded				●				●								●		●	●	●	●	○	●	●		
	Lube Oil Needs Changing														●						●	●	○				
	Engine Exterior Caked with Dirt																●		●	●							
MECHANICAL ADJUSTMENTS OR REPAIR	Gasket Blow-by or Leakage			●	●	●										●											
	Faulty Vibration Damper																								●		●
	Unbalanced or Loose Flywheel																								●		●
	Valve Leakage	●	●			●																	○				
	Broken or Worn Piston Rings			●	●	●								●							●				●		
	Incorrect Bearing Clearances					●			●								●					●			●	●	
	Excessive Crankshaft End Clearance																					●			●	●	
	Main Bearing Bore Out of Alignment																					●			●		●
	Engine Due for Overhaul	●		●	●	●			●					●			●				●	●	●		●	●	●
	Damaged Main or Rod Bearings																●					●			●		
	Broken Tooth in Gear Train																								●	●	
	Excessive Gear Back Lash																								●	●	
	Misalignment Engine to Driven Unit								●													●				●	●
	Loose Mounting Bolts																								●		●
	Incorrect Valve and Injection Timing	●		●	●	●																	●	●	●		
	Worn or Scored Liners or Pistons			●	●	●								●							●				●		
	Injectors Need Adjustment		●	●	●	●			●		●	●	●											●			

Maintenance Operations

Maintenance is the key to lower operating costs. Cummins Diesel engines – like any other engine – requires regularly scheduled maintenance to keep them running efficiently. Most engines are purchased and used for the sake of revenue. Any failure or loss of efficiency reduces revenue as well as requiring additional funds for repair.
Investigate any successful operation where engines are used and you will find a good, regularly scheduled maintenance program in effect.

Maintenance Schedule

Preventive maintenance performed on schedule is the easiest, as well as the least expensive, type of maintenance. It permits the maintenance department to schedule their work in the shop at a convenient time, rather than on the job under poor working conditions and/or at inconvenient hours.

Accessories must have a place in the maintenance schedule the same as basic engine; an accessory failure may put entire engine out of operation.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of engine must govern establishment of maintenance schedule. For V-470-M marine operation and maintenance consult Bulletin 983648. Some engines operate under rather clean conditions, some under moderately dusty conditions and others under severely dusty or dirty conditions, and each type operation must be analyzed as the maintenance schedule is established. A look at the suggested check sheet, on the next page, indicates some checks "AC" may have to be performed more often under heavy dust or other adverse conditions. The schedule is also dependent upon amount of work being done which can best be determined by amount of fuel being burned. A record of gallons of fuel used is the best yardstick to be used in establishing an accurate regular maintenance schedule.

Hours of operation may be used for the same purpose; in so doing, you should determine amount of fuel used per hour during normal operation. For example, if the average fuel consumption of an engine is 4 gal [15.140 lit 3.3307 UK gal] per hour the "B" check would be made every 1200 gal [4542.36 lit 999.2040 UK gal] of fuel or approximately every 300 hours of operation.

Miles traveled also should be set up on the basis of fuel used; after this is established, miles traveled record can be used in setting up the maintenance schedule. For example, if the average fuel consumption of an engine is 10 mi. [16.09 km] per U.S. gal [3.785 lit/0.83267 UK gal] the "B" check would be made every 5000 mi. [8046.500 km]. This figure would then be inserted for the "B" check,etc.

Calendar Maintenance

The calendar maintenance period is normally used in applications where low mileage [km] is recorded and the unit is not equipped with an hourmeter. An example is a pick-up and delivery vehicle which operates a few miles [km] per month but may be running at idle speeds for long periods and would accumulate less than 150 hours per month. See Table 5-1, Page 5-3.

Extending Maintenance Schedule

Any change of established maintenance schedule should be preceded by a complete re-analysis of the operation. A lubricating oil analysis should be the major factor used in establishing original maintenance schedule and it should be studied before making any change in or extending schedule periods. In extremely dirty and under severe operating conditions, scheduled maintenance period may even need reducing. Again, operation should be re-analyzed and a lubricating oil analysis should be made. Extending or reducing schedule period should be done only after a complete study, basically, the same as used in establishing original maintenance schedule period. Lubricating oil analysis is described on Page 5-8.

Using Suggested Schedule Check Sheet

The maintenance schedule check sheet (on next page) is designed as a guide until you have adequate experience to establish a schedule to meet your specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for gallons of fuel used, hours of operation or under some conditions a calendar period. See Table 5-1.

Your maintenance schedule should be established using the check sheet as a guide; the result will be an excellent maintenance program to fit your specific operation.

The check sheet shown can be reproduced by any printer to provide forms for your use. The person making each check

Maintenance Schedule

CHECK SHEET

EQUIPMENT NO.________ ENGINE SERIAL NO.________

MECHANIC________ MILEAGE, HOURS, GALLONS________

TIME SPENT________ CHECK PERFORMED________

PARTS ORDER NO.________ DATE________

NOTES:

1. The "AC" check indicates those maintenance checks that should be performed at a more frequent interval when engine operates under extreme weather, highly dusty or other adverse conditions.
2. This schedule is based upon use of only a full-flow oil filter, if by-pass is used extend oil changes by 50% (8,000 to 12,000 miles, etc).

See Table 5-1, Page 5-3 For Suggested Maintenance Intervals

Check (✓) In Blank Space, Under Appropriate Interval As Each Operation Is Performed	**Daily A**	**AC**	**B**	**C**	**D**	**E**
Full Instructions Begin On Page	**5-4**	**5-7**	**5-8**	**5-19**	**5-26**	**5-27**
Check Operator's Report						
Check Leaks and Correct						
Check Engine Oil Level						
Check Coolant Level						
Fill Fuel Tanks						
Drain Fuel Filter						
Drain Air Tanks						
Check Converter Oil Level						
Lubricate Industrial Clutch Bearing						
Check Oil Bath Cleaner Oil Level						
Clean Air Pre-Cleaner Dust Pan						
Change Engine Oil						
Change Full Flow Oil Filter						
Change By-Pass Oil Filter						
Record Oil Pressure						
Drain Sediment/Clean Fuel Tank Breather						
Change Fuel Filter						
Air Cleaner Restriction						
Clean Dry-Type Cleaner Element						
Clean (External) Radiator Core						
Change Oil Bath Cleaner Oil						
Clean Oil Bath Cleaner Tray Screen						
Change/Clean Crankcase Breather						
Check Air Piping						
Check Throttle Linkage						
Check Fuel Pump Screw Seals						
Check Engine Coolant/Change Resistor Element						
Steam Clean Engine						
Check Air Intake Manifolds						
Lubricate Water Pump/Fan Hub						
Check and Adjust Belts						
Clean Fuel Pump Screens						
Adjust Injectors/Valves						
Check Fuel Manifold Pressure						
Check Vibration Damper						
Clean Complete Oil Bath Air Cleaner						
Check Alternator/Generator/Crank Motor						
Check Air Compressor Unloader Valve						
Check Crankshaft Mounted Fan						
Tighten Engine Mounting Bolts						
Rebuild Water Pump/Fan Hub						
Clean and Calibrate Injectors						
Check Fuel Pump Calibration						
Rebuild Cylinder Head						
Inspect Bearings						
Replace Cylinder Liner Seals						
Replace Piston Rings						
Rebuild Air Compressor						
Rebuild Injectors						
Replace Front/Rear Crankshaft Seals						
Rebuild Fuel Pump						
Replace Vibration Damper						

For "AC" Checks See Notes At Left

Full Instructions For Following Begin On Page 5-28		
Check Radiator Shutters/Adjust—As Needed		
Clean Cooling System—Spring and Fall		
Check Hose/Replace as necessary—Spring and Fall		
Check Thermostats and Seals—Fall		
Check Cold Starting Aid—Fall		
Clean Electrical Connections—Fall		
Check Crankshaft End Clearance—At Clutch Adjustment		
Check Fan Mounting—Spring and Fall		
Change Converter Oil/Filter—See Manufacturer Recommendations		

can then indicate directly on the sheet (in the blank box following the operation) that he has completed the operation. When a complete column (under A, B, C etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Maintenance Operations Summary Sheet

The maintenance operations summary sheet (at the end of this section) is designed to be used to summarize scheduled maintenance checks for a specific engine, by unit or engine serial number. The summary sheet records operation or check performed, fuel used, mechanic, labor costs, parts used, etc. A complete record of this type is essential to perform a thoroughly efficient cost record of the operation.

Maintenance – Standby Service Engines

For units in standby service when hours of operation fall far below those listed, adjust the maintenance schedule accordingly as follows and with due consideration:

1. Monthly perform A checks.
2. Every 5 months, perform B checks.
3. Every 9 months, perform C checks.
4. Every 3 years, perform D checks.
5. Every 5 years, perform E checks.

Lubricating oil standing in engines that are used infrequently or are in storage between seasons may tend to oxidize and require changing even though it is not dirty. Laboratory testing is the best way to determine whether oil or fuel is oxidizing under these conditions, and we suggest that oil be checked regularly. After several tests it will be possible to schedule oil changes where the oil is not actually being contaminated due to dirt.

Units in standby service should be started once each week in locations where ambient temperature remains below 70 deg. F [21.1 deg. C] and contains a high percentage of humidity. Start engine and bring unit up to normal operating temperature and run for approximately thirty minutes. Check electrical equipment for corrosion on all relays and switch terminals. Check controls for leaks and proper operation.

With units in locations where ambient temperature is normally above 70 deg. F [21.1 deg. C], perform starting procedure as above once every two weeks.

The above procedures are only recommendations; therefore, the operator must take into consideration the environment of his particular unit installation.

Storage For Engines Out Of Service

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Contact your nearest Cummins Distributor for information concerning engine storage procedures.

Table 5-1: Suggested Base Maintenance Intervals

Interval Basis	Models	A	AC	B	C	D	E
Hours Operation	6 & 8	Daily	100	300	1,200	3,600	6,000
Miles Operation	6	Daily	2,500	6,000	Oil Change Only – See Note 1		
(See Note 1)	6 & 8	Daily	2,500	8,000	32,000	100,000	180,000
U.S. Gallons	6	Daily	400	1,200	3,600	14,400	24,000
Fuel Used	8	Daily	525	1,600	4,800	19,200	32,000
Calendar	6 & 8	Daily	Month	3 months	1 year	3 years	5 years

Notes:

1. The oil change period on the six cylinder engine is to be performed at 6000 miles; however, all other maintenance operations can be performed at same period as the eight cylinder engine.
2. "AC" intervals apply to engines in dusty applications only.
3. If a Cummins Fleetguard LF-500 by-pass oil filter is used the oil change and by-pass filter change period may be extended 50% (6,000 to 9,000 or 8,000 to 12,000 miles, etc.).
4. Maintenance periods should be established on the operating basis fitting operating conditions or whichever interval occurs first (300 hours if it occurs before three months, etc.). Under normal conditions the calendar interval basis is only used where operation is less than 2,000 miles a month.
5. The safest and most economical method for determining oil change period by lubricating oil analysis; see Page 5-8.

A—Maintenance Checks

Check Operator's Report

Check operator's daily or trip reports, and investigate and correct reported cases of:

1. Low, high or change in lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noises.
5. Excessive smoke.
6. Excessive use of coolant, fuel or oil.
7. Observe all instruments and gauges (with coolant temperatures in operating range) with engine running at most applicable speed; take any corrective action required.

Check Leaks And Correct

Lubricating Oil

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. See that they are tightened securely. Fig. 5-1.

Fuel Oil

1. Check for evidence of fuel leakage.

a. Check fuel pump and filter.

b. Check fuel supply line and connections at fuel tank, fuel filter and fuel pump.

c. Check fuel inlet line and connections at fuel pump shutdown valve.

d. Check all fuel supply and drain lines, connections and fittings on cylinder heads.

e. Check fuel lines between engine and fuel tank(s).

2. If there are indications of air leaks on suction side of fuel pump, check for air leaks by placing ST-998 Sight Gauge (1, Fig. 5-2) in the line between fuel filter(s) and pump. Bubbles over 1/2 in. [12.70 mm] long or "milky" appearance indicates an air leak. Find and correct.

Coolant

Check for evidence of external coolant leakage. Tighten capscrews, hose clamps, fittings and connections or replace gaskets or hose as necessary to correct.

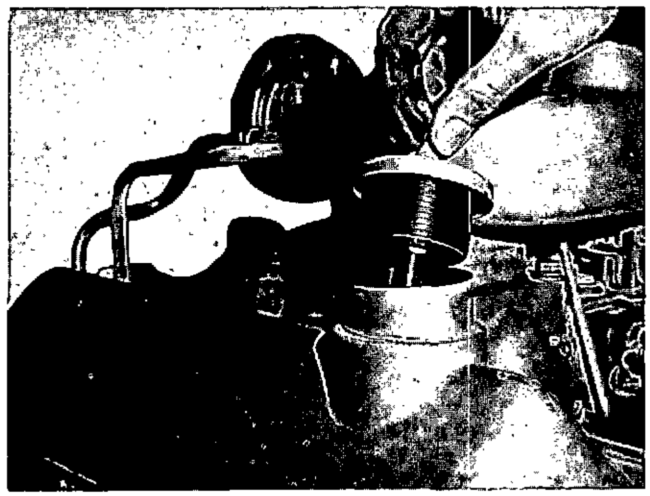


Fig. 5-1, V11903. Lubricating oil filler tube

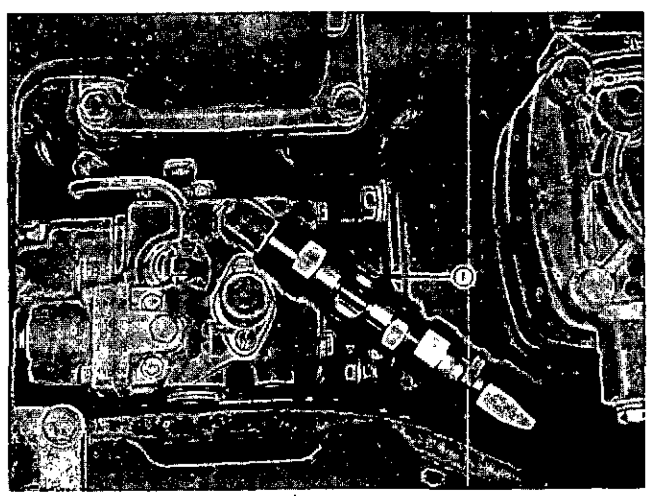


Fig. 5-2, V11965. ST-998 Sight Gauge installed in fuel suction line

Air Connections

Visually check air system connections for leaks or damage while making other visual checks.

The diesel engine requires hundreds of gallons (liters) of air for every gallon (liter) of fuel that it burns. For engine to operate efficiently, engine must breathe freely; intake and exhaust systems must not be restricted.

Valves, pistons and rings must seal properly against compression and combustion pressures.

The amount of fuel that can be burned and power developed is as dependent upon air as fuel. If there is too little air to burn all the fuel, the excess fuel causes a smoky exhaust – high exhaust temperatures and a loss of horsepower.

Wasted fuel is not the only loss caused by incomplete combustion. The excess fuel washes lubricating oil off cylinder walls resulting in seized pistons and bearing failures. Carboned injector cup spray holes and stuck piston rings are other troubles which result from insufficient air. Dirty air cleaner elements, leaky valves, worn rings, damaged silencers and air piping that is too small or with sharp bends are common causes of air restriction. Therefore, it is necessary to perform air system maintenance regularly.

Note: When engines operate under extremely dusty conditions, adjust the maintenance intervals to those indicated by blocks marked "AC" in the check sheet on Page 5-2.

Engine Oil Level

1. Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked for approximately 15 minutes after engine shutdown. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" mark as possible. Fig. 2-2.

Caution: Never operate the engine with oil level below the "L" mark or above the "H" mark.

2. Add oil as necessary of the same quality and brand as already in engine. See Page 3-2.

Lubricating oil performs four functions in an engine:

1. Reduces friction (heat and wear) by providing a film between bearing surfaces.
2. Scavenges by picking up carbon and other small particles, carrying them to the oil filter where they are taken out of circulation.
3. Cools pistons, liners and bearings and absorbs heat from the engine. This heat is then dissipated by radiation from the pan and by an oil cooler (if used). It is important that air be free to flow around the oil pan.
4. Completes the seal of rings to pistons and cylinder walls.

There are two broad classes of lubrication failures:

1. Those caused by running an engine without or low on oil, resulting in seizures of pistons or bearings within minutes.
2. Failures due to poor or marginal lubrication, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

Check Coolant Level

Keep cooling system filled to operating level. Check coolant level daily or at each fuel fill up. Investigate for cause of coolant loss if loss is noticeable. Recheck the level after engine reaches normal operating temperature. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets. Requirements of a good coolant are described on Page 3-4.

Many operators have been shocked to find water in crankcase and to learn it got there through "pin holes" or pitted areas that started on water side of cylinder liners.

This "eating away of metal" or corrosion, as it is commonly called, is likely to occur in any heating or cooling system. Corrosion may or may not be associated with iron rust, and as a result may not show up in the coolant.

Research has shown there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained corrosion resistor.

Aeration refers to air bubbles which may be drawn into radiator core tubes, then into water pump and engine. The worst effect of aeration is loss of water pump prime due to an accumulation of air resulting in complete flow stoppage. Entrained air promotes accelerated internal corrosion. Entrained air in coolant will increase the temperature differential from combustion gases to water due to reduction in heat transfer.

An open (non-baffled) radiator top tank is often the cause of air entering the system. Due to high velocity of coolant entering top tank, the surface becomes very agitated and tends to draw air into core tubes along with coolant. It is very difficult on many units to completely fill cooling system at initial fill; this is due to trapping of air in pockets in engine or other parts of the system. The system should be bled of air or refilled after a short period of operation to purge air from the coolant.

Fill Fuel Tanks

Always filter or strain fuel before or while putting it in tank. See "Fuel Oil Specifications", Page 3-1.

In cold weather, water which accumulates in the fuel system will sometimes freeze and block the supply of fuel.

This condition can be prevented by adding one quart of denatured alcohol to each 50 gal [189.250 lit or 41.6335 UK gal] of fuel oil.

This not only prevents the water from freezing, but allows it to go into solution with the alcohol and fuel oil so it can pass through the fuel system and be "burned" without doing any damage.

Fuel should always be strained or filtered before being put into the supply tank. This will lengthen the life of the engine fuel filter and reduce the chances of dirt getting into the fuel pump and injectors.

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged from overuse will be more of a handicap than help to an engine. It will restrict the flow of fuel, thus reducing horsepower output.

Excessive amounts of water in the fuel will cause rusting and corrosion in the injectors as well as to fuel pump shafts, bearings and other parts. In some sections it is difficult to purchase fuel which does not contain some water. Normal condensation, either in the storage tank or in the fuel tank, increases water content. This water, of course, must be filtered out or drained off before it gets into the fuel pump. The life of fuel pump and injectors can be considerably extended if the operator takes the precaution of draining about a cup of fuel from the lowest point in the fuel system before starting the engine each day.

Drain plugs are located in the bottom of some fuel filter cases, and in the sump of the fuel supply tank. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm fuel returning from the injectors heats the fuel in the supply tank. If the fuel level is low in cold weather, the upper portion of the tank not being heated by returning fuel tends to increase condensation. In warm weather both the supply tank and fuel are warm. In the night, however, the cool air lowers the temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

Drain Fuel Filter

1. Open drain cock, if used, at bottom of fuel filter case and drain out any accumulated water and sediment. Close the drain cock. If drain plug is used, tighten to 5 to 10 ft lb [0.6915/1.3830 kg m].

2. Unscrew throw-away type element (without drain cock); dump water and sediment. Fill element with clean fuel and replace.

Drain Air Tank(s)

Open drain cock(s) and drain all moisture and sediment from air tank(s). Quantity of condensation will be dependent on local humidity.

Check Converter Oil Level

Different models of equipment may vary in the manner in which oil level check is made — with a dipstick, a level plug or a petcock. Oil level should be maintained at full. If needed, add oil according to oil specifications on nameplate.

1. Cold Check:

   The cold check (engine not running) insures there is sufficient oil in system to start engine — especially if equipment has been standing idle for a long period of time. Be sure oil is at high level.

2. Hot Check:

   The hot check should be made at operating temperature, with the engine running from 600 to 1000 rpm and with the transmission in neutral range.

3. If the converter is operating in combination with a Torqumatic transmission, the oil level check is made at the transmission.

Lubricate Power Take-Off And Clutch Throw-Out Bearing

Follow manufacturer's instructions, if available. If manufacturer's instructions are not available, following recommendations are suggested:

Power Take-Off

Apply a small amount of any high-grade soda base, short fiber, heat resistant, gun lubricant grease once a day through fitting on tapered part of housing to throw-out collar.

Manual Spring-Loaded Input Disconnect Clutch

Approximately once a week, lubricate the release bearings with two "shots" from a grease gun using above grease. Two grease fittings are usually provided atop the clutch housing.

AC–Maintenance Checks

The maintenance checks listed under "AC" column of the check sheet are those which must be performed at more frequent intervals when engine is operating under adverse conditions. The frequency of the intervals is dependent upon actual operating conditions and will vary with intensity of the dust, dirt or extreme weather conditions. Applications normally considered to be dusty are dry cement haulers, construction, mining, etc.

If the above conditions apply to engines being maintained we suggest you work with your local Cummins Distributor in establishing a maintenance schedule for your particular operation. Items like "Clean Air Precleaner Dust Pan" may have to be performed at each shift or sooner.

Detailed instructions for performing the "AC" checks not covered under the following two headings are described as a part of the "B" Maintenance checks.

Check Oil Bath Air Cleaner Oil Level

Daily, check oil level, Fig. 5-3, in oil bath air cleaner to be sure oil level in oil cup is at indicated mark. To remove oil cup, loosen wing nuts. During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes cleaner to become flooded and results in oil pullover or plugging of the bottom air cleaner screen. Add or change oil as necessary. This is especially important if oil bath cleaner is the only cleaner on the engine.

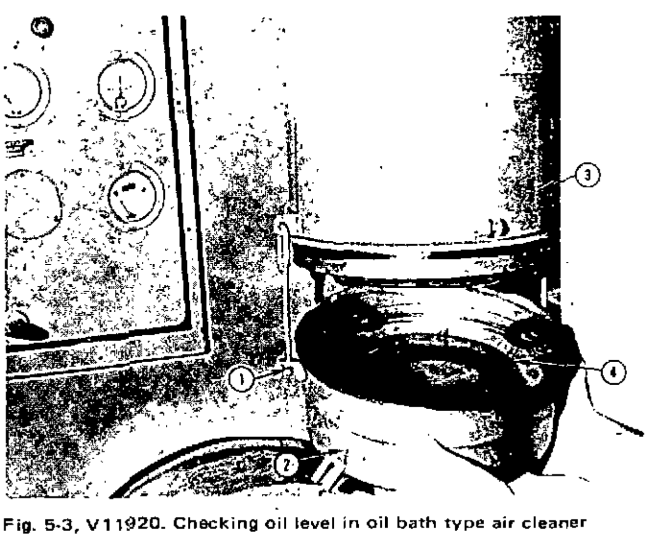


Fig. 5-3, V11920. Checking oil level in oil bath type air cleaner

Clean Pre-Cleaner And Dust Pan

On engines working under extremely dirty conditions an air pre-cleaner may be used. Clean pre-cleaner jar and dry-type air cleaner dust pans daily or more often as necessary depending on operating conditions.

B–Maintenance Checks

At each "B" maintenance check, perform all "A" and "AC" checks in addition to the following.

Engine Oil Change

Perform at AC Check under extremely dusty conditions.

Kind of oil used (Mil-L-2104A, Supplement 1, Mil-L-2104B, etc.) efficiency of filtering system and condition of engine must be considered in determining when to change oil.

Recent tests using Cummins Fleetguard full-flow paper element filter in combination with a Fleetguard by-pass filter, Supplement 1 oils, and using oil analysis with filter restriction measurement indicate a naturally aspirated on-highway truck may have oil change period extended as much as 50% under closely controlled conditions. This indicates economy that can be obtained through a good maintenance program.

It is suggested that oil change periods be set up on schedule indicated in Table 5-2 and then extended, or in unusual cases reduced, based upon type oil used and other items as described in above paragraph.

Factors to be checked and limits for oil analysis are listed below. Oil change at "B check" as shown in maintenance chart on Page 5-2 is for use where only full-flow paper element filter is used.

Change Engine Oil

1. Bring engine to operating temperature; shutdown engine (allow enough time for all oil to drain back into oil pan) remove drain plug from bottom of oil pan and drain oil in suitable container.
2. Install drain plug in oil pan and torque to 35/40 ft-lbs [4.8405/5.5320 kg m].
3. Fill crankcase to "H" (high level)) mark on dipstick.
4. Start engine and visually check for oil leaks.

   Note: It is important to visually check for oil leaks after every oil and/or filter change.

5. Shut down engine; allow 15 minutes for oil to drain back into pan; recheck oil level with dipstick. Add oil, as required, to bring oil level to "H" mark on dipstick.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using a laboratory test. After several test periods, a time interval (gallons fuel consumed, hours, weeks, etc.) for the oil change can be established; however, a new series of tests should be run if filters, oil brands or grades are changed.

In the beginning, tests should be made each 100 US gal [378.5 lit – 83.3 UK gal] fuel consumed (after the first 200 US gal [757 lit – 166.6 UK gal], or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary. Repeat analysis cycle until a definite pattern is established.

Wide variations in different brands of lubricating oil make it profitable to contact the oil supplier to assist in the development of the oil change period because he knows best the factors peculiar to his brand or brands of oil.

Table 5-2: Suggested Initial Oil and Filter Change Periods

Filtering Arrangement	Engine Model	Fuel Used	Driving Distance	Hours Operation
Full-Flow Paper Element Only	V6	1200US gal [4542 lit]	6000 mi. [9655 km]	300
	V8	1600 US gal [6056 lit]	8000 mi. [12,874 km]	300
Full-Flow and By-Pass	V6	1800 US gal [6813 lit]	9000 mi. [14,483 km]	450
	V8	2400 US gal [9024 lit]	12000 mi. [19,311 km]	450

Note: 1200 US gal = 999 UK gal, 1600 US gal = 1332 UK gal, 1800 US gal = 1498 UK gal and 2400 US gal = 1998 UK gal

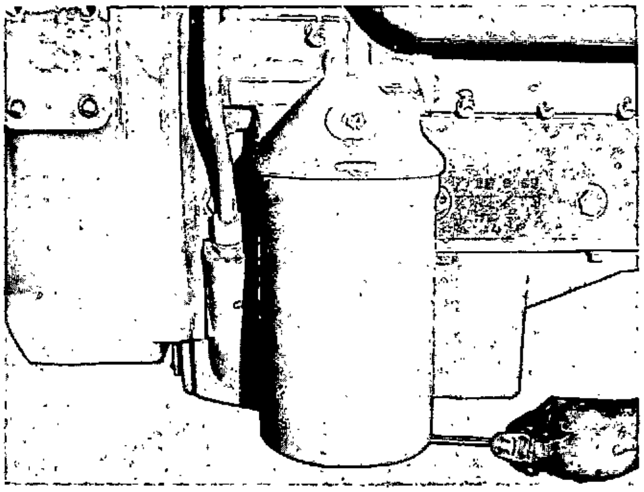


Fig. 5-4, V11904. Removing full-flow lubricating oil filter case

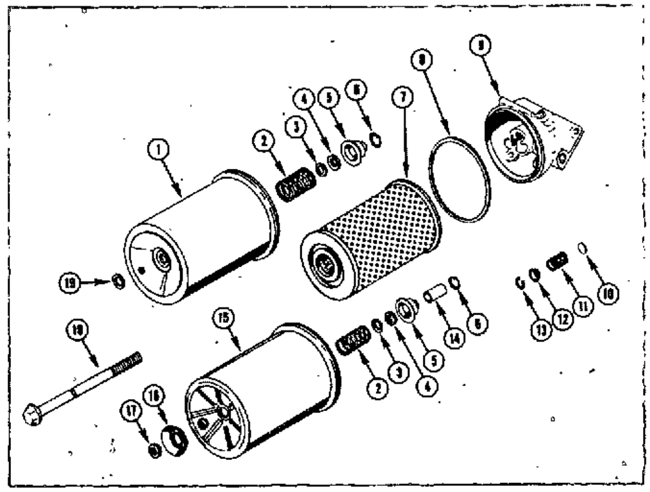


Fig. 5-5, V10702. Full-Flow filter assembly

Analysis Test For Lubricating Oil

Following is a suggested list of lubricating oil properties which should be checked during laboratory analysis. The suggested methods are fully described in the American Society for Testing Materials Handbook.

Oil Property	Test Number
Viscosity at 100 deg. and 200 deg. F [37.8 deg. and 93.3 deg. C]	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

General Limits For Oil Change

1. Minimum Viscosity (dilution limit): Minus one SAE grade from oil being tested or point equal to a minimum containing five percent by volume of fuel oil.

2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210 deg. F. [98.9 deg. C] or 25 percent increase at 100 deg. F [37.8 deg. C].

3. Sediment Content: Normal pentane insoluble 1.0 to 1.5 percent. Benzine insoluble 0.75 to 1.0 percent.

4. Acid Number: Check with your oil supplier as this value differs with each oil brand and grade.

5. Water Content: 0.2 percent maximum.

6. Additive Reduction: 25 percent maximum.

Caution: If the above tests indicate presence of any bearing metal particles, or if found in filters, the source should be determined before a failure results.

The efficiency of any maintenance program can only be judged on the basis of failures prevented or intercepted before engine or unit is damaged.

Change Engine Full-Flow Filter Element

Perform at "AC" Check under extremely dusty conditions.

1. Loosen and completely unscrew center capscrew and remove filter case from filter head. Fig. 5-4.

2. Withdraw filter element, inspect, then discard.

a. Inspect for metal particles.

Caution: If metal is found, a check of connecting rods and main bearings should be made at once.

b. If element is relatively clean it may be possible to lengthen change periods.

c. If element is clogged the change period should be shortened. Oil pressure drop reading across filter is the best way to determine change periods. Pressure drop from inlet to outlet side of filter should not exceed 10 psi [0.7030 kg/sq cm] with 140 deg. F [60 deg. C] oil and engine at high-idle speed.

3. Remove seal ring that may have stuck to filter head or spring loaded guide in can and discard.

Caution: Two or more seal rings attached to filter head will cause leakage, permitting unfiltered oil to by-pass element.

4. Clean filter case thoroughly. Handle case and/or store in manner to prevent out-of-round.

Note: It is recommended that every second oil change to change the small seal rings (4 & 17, Fig. 5-5) at bottom of oil filter can to prevent oil leakage due to hardening of rubber seals. Inspect seals each oil change for deterioration.

5. Check to make sure element end seals are in place and install new element over spring support assembly.

6. Assemble filter case with new element and make sure the element seats on its seal (on the spring loaded seal retainer in the can) and that the upper element seal ring fits over the filter head pilot; position assembly to filter head and tighten center capscrew to 25/35 ft-lb. [3.4575/4.8405 kg m].

Caution: Never attempt to fit new seal ring to filter can or gasket may become distorted or damaged.

7. Check engine oil level, fill as necessary. Run engine and check for leaks.

8. Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

Note: Always allow oil to drain back to oil pan before checking level.

Change By-Pass Filter Element

Perform at "AC" Check under extremely dusty conditions.

Change Cummins Fleetguard by-pass filter elements on engine so equipped as follows:

1. Remove drain plug (5, Fig. 5-6) from bottom of housing and drain oil.

2. Remove clamping ring capscrew (1) and lift off cover.

3. Unscrew upper support hold-down assembly (3); lift out element (4) and hold-down assembly. Discard element.

4. Clean housing and hold-down assembly in solvent; clean orifice (6) in standpipe.

5. Inspect hold-down assembly spring and seal. Replace if damaged.

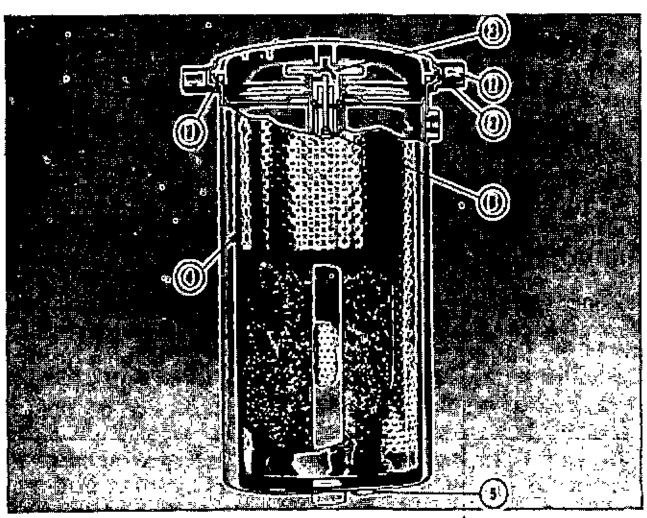


Fig. 5-6, V41908. By-pass filter cross section

6. Inspect drain plug and connections. Replace plug.

7. On the Cummins Fleetguard by-pass filter, check orifice plug (6) inside oil outlet connection or standpipe; blow out with air jet to make sure orifice is open and clean.

8. Check filter cover "O" ring (7). Replace if damaged or deteriorated.

9. Install new element in housing.

10. Replace upper support hold-down assembly on filter and tighten down to stop.

11. Position "O" ring seal on housing flange.

12. Install cover and clamping ring; tighten capscrew until clamping lugs come together. The male lug should mate in the female clamp on both sides.

13. Add enough extra oil to crankcase to fill case and element.

Caution: Never use a by-pass filter in place of a full-flow filter.

Record Oil Pressure

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140 deg. F [60 deg. C]. Reduce engine speed to idle and record oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Clean Fuel Tank Breather(s) And Drain Sediment From Tank(s)

Perform at "AC" Check under extremely dusty conditions.

1. Clean tank breather(s) in cleaning solvent and dry with compressed air.

2. Loosen fuel tank drain cock(s) or plug(s) and drain approximately 1 cup of fuel or until all sediment is removed. Close drain cock(s) or install plug(s).

Change Fuel Filter Element

Perform at "AC" Check under extremely dusty conditions.

Change the single 5 3/4 in. [146.050 mm] long (throw-away) fuel filter after 1800 US gal [6813.00 lit — 1498.806 UK gal] of fuel consumption. Change the single 7 1/2 in. [190.500 mm] long (throw-away fuel filter) after 2800 US gal [10,598.000 lit — 2331.476 UK gal] of fuel consumption and the stack disc (replacement element) after 4000 US gal [15,140.000 lit — 3330.680 UK gal] fuel consumption.

When double elements of the standard or extended life (throw-away) fuel filters are used, the capacity is approximately doubled.

Note: Capacities listed above are under normal working conditions and with proper storage of fuel.

The most accurate method of determining element change period is by measurement of fuel restriction as outlined below.

Check Fuel Restriction

To check restriction, connect ST-434 Vacuum Gauge to fuel pump as shown in Fig. 5-7 using special adapter furnished. If restriction reads 8 to 8.5 in. [203 to 215 mm] vacuum while engine is running at full speed and load, change element or remedy other sources of restriction.

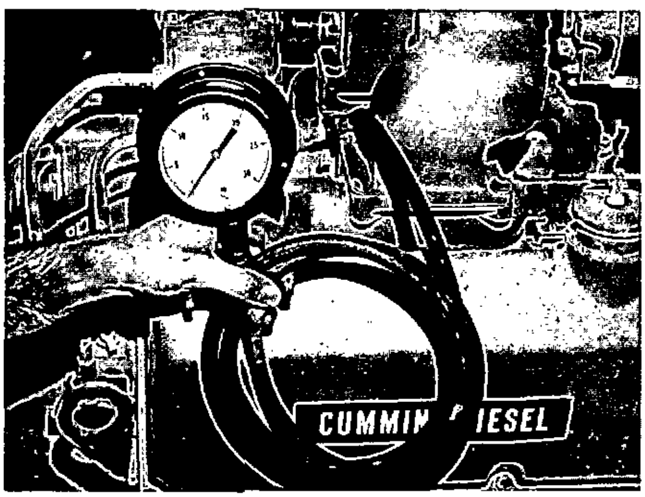


Fig. 5-7, V11908. Checking fuel filter restriction

Change element as described below.

Replaceable Element Type Filter

1. Open drain cock(s) in bottom of filter case(s) and drain contents.

2. Loosen nut(s) at top of fuel filter(s). Take out dirty elements, clean filter case(s) and install new element(s).

3. Install new gasket(s) in filter head(s) and assemble case(s) and element(s). Tighten center bolt(s) to 20/25 ft-lb [2.766/3.4575 kg m] with a torque wrench. Fill filter case(s) with clean fuel to aid in faster pick-up of fuel.

4. Check fittings in filter head(s) for leaks. Fittings should be tightened to 30/40 ft-lb [4.1490/5.5320 kg m].

Throw-Away Type Filter

1. Unscrew combination case(s) and element(s) (1, Fig. 5-8); discard.

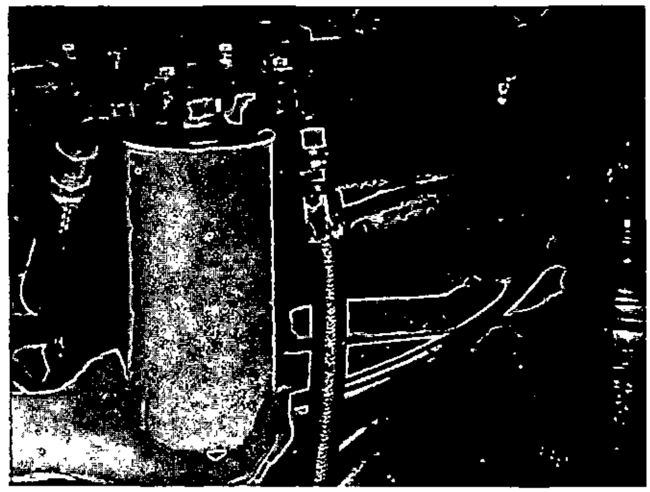


Fig. 5-8, V11909. Removing throw-away type fuel filter

Note: On elements that do not have integral "O" ring seal(s), install new "O" ring(s) before installing element(s).

2. Fill element(s) with clean fuel.

3. Install new element(s); tighten by hand until seal touches filter head. Tighten an additional one-half to three-fourths turn.

Caution: Mechanical tightening will distort or crack filter head(s).

Check Inlet Air Restriction Gauge

Perform at AC Check under extremely dusty conditions.

The best method for determining dry-type air cleaner maintenance periods is through air restriction checks.

Check Air Inlet Restriction At Cleaner

1. A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The restriction indicator signals when to change cartridges. The red flag (1, Fig. 5-9) in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge, reset indicator by pushing re-set button (2). Push button all the way in firmly; then release. If button sticks, repeat pushing slowly.

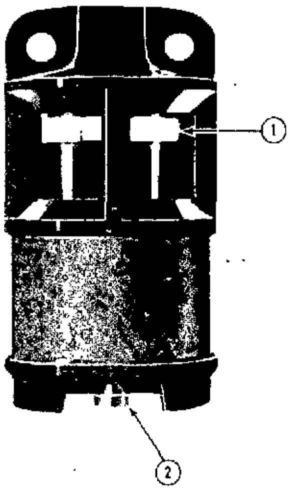


Fig. 5-9, V51001. Air inlet restriction gauge

Note: Never remove felt washer from gauge; it is necessary to absorb moisture.

2. Vacuum switches are available which actuate a warning light on instrument panel when air restriction becomes excessive. Items required for installation are:

a. Electric source (1, Fig. 5-10).

b. Air intake connection with fitting for switch (2).

c. Vacuum switch (3).

d. Red indicator light (4).

Note: Air restriction checks should not be used to determine maintenance periods for oil-bath air cleaners. Before dirt build-up reaches 1/2 in. [12.700 mm] maximum height, perform maintenance as described under "Change Oil Bath Air Cleaner Oil".

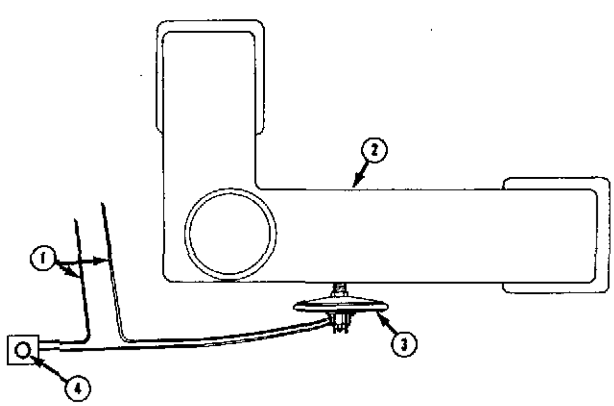


Fig. 5-10, V11010. Vacuum switch to check air inlet restriction

Check Air Inlet Restriction At Engine

Where a restriction gauge is not part of system, check as follows:

1. On naturally aspirated engines attach vacuum gauge or water manometer in middle of intake manifold or on air intake crossover. See Fig. 5-10.

2. Idle engine until normal operating temperature is reached.

3. Operate engine at rated speed and take reading from vacuum gauge or manometer. Air restriction must not exceed 20 in. [508.0 mm] of water or 1.5 [38.100 mm] of mercury if a V-352 or V-470 series engine; if checking a V-378 or V-504 engine, air restriction should not exceed 25 in. [635.0 mm] of water or 1.8 in. [45.720 mm] of mercury.

4. If air restriction exceeds limits above (step 3), proceed as follows:

a. Clean or replace dry-type cleaner element.

b. Replace damaged air piping, rain shield or housing.

c. Remove excessive bends or other source of restriction in air piping.

Clean Air Cleaner Elements

Perform at AC Check under adverse conditions.

Dry Type

The paper element in a dry-type air cleaner, Fig. 5-11, may be cleaned several times by using an air jet to blow off dirt or by washing with non-sudsing household detergent and warm water, preferably 120/140 deg. F [48.9/60.0 deg. C], then drying with compressed air, approximately 40 psi [2.8124 kg/sq cm]. Do not hold air jet too close to paper element or damage to element may result.

Elements that have been cleaned several times will finally clog and air flow to engine will be restricted. After cleaning, check restriction as previously described and replace element, if necessary.

Holes, loose end seals, dented sealing surfaces and other forms of damage require immediate element replacement.

Replace paper element in *all* dry-type air cleaners when breaks appear or if air restriction is still excessive after element has been cleaned. To change element:

1. Loosen wing nut (1, Fig. 5-11) securing bottom cover (2) to cleaner housing (3). Remove cover.

2. Pull element (6) down from center bolt (4).

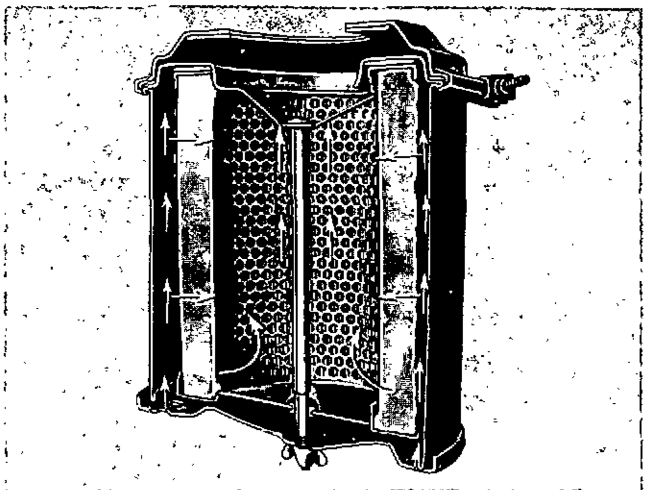


Fig. 5-11, N11003. Air cleaner - dry type

3. Remove gasket (5) from outlet end (7) of housing.

When installing the element, make sure it seats on the gasket at the air cleaner outlet end.

Caution: Holes in the element of a dry-type air cleaner render cleaner inoperative. Do not use damaged cleaner element.

Cyclopac And Donaclone Types

The Cyclopac and Donaclone air cleaners combine a centrifugal cleaning stage with a paper filter element. Fig's. 5-12 and 5-13.

On the Cyclopac model, dirty air enters through an opening in the side of the cleaner body, where it immediately travels through a ring of vanes around the outside of the element.

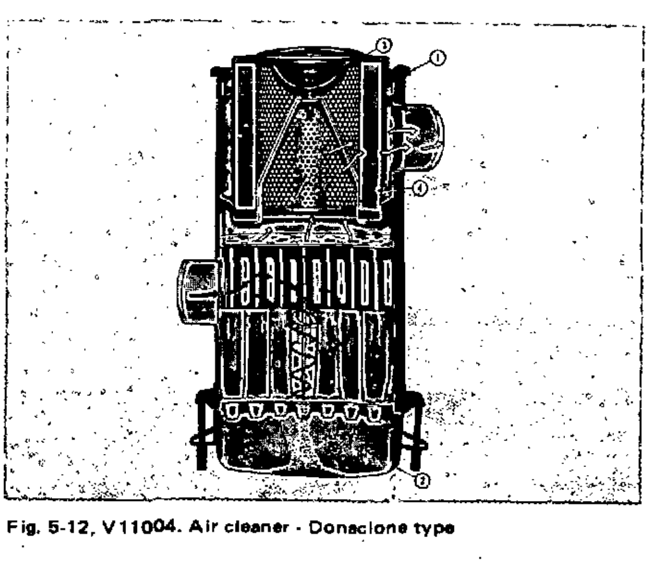


Fig. 5-12, V11004. Air cleaner - Donaclone type

These vanes impart a cyclonic twist to the air, thereby throwing dust and dirt particles outward and down into the dust cup. The air then passes through the element (from the outside) and on into the engine.

On the Donaclone model, dirty air enters through an opening in the top or side of the cleaner body, where it enters plastic tubes. These tubes contain vanes which impart a cyclonic twist to the air, thereby throwing dust and dirt particles outward and down into the dust cup. The air then travels up through the aluminum tubes inside the plastic tubes, through the filter element (from the inside) and on into the engine.

Before disassembly, wipe dirt from cover and upper portion of air cleaner. To clean composite-type:

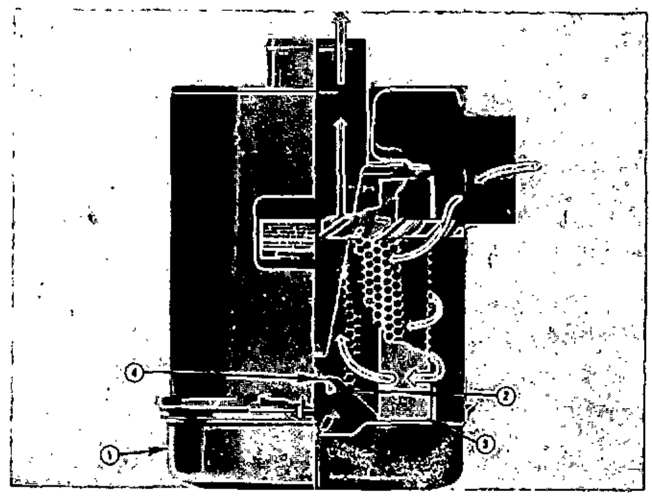


Fig. 5-13, V11005. Air cleaner - Cyclopac type

1. Loosen clamps and remove cover (1, Fig. 5-13).
2. Unscrew wing bolt holding inner cover and element (3, Fig. 5-12) (4, Fig. 5-13) in position; remove element carefully so that loose dirt will not fall into chamber (2, Fig. 5-12) (3, Fig. 5-13).
3. Remove dust cup (1, Fig. 5-12) (2, Fig. 5-13) and clean.
4. Tap side or bottom ring of element with palm of the hand or soft hammer.
5. Blow out element from clean air side with compressed air.

Caution: Air pressure should not be more than 100 psi [7.0310 kg/sq cm] to avoid rupturing element. Do not concentrate air pressure in one spot.

6. Wash element with non-sudsing household detergent and warm water (120/140 deg. F [48.8/60.0 deg. C]). Dry with compressed air (40 psi [2.8120 kg/sq cm]).

7. Remove retainer clamp. Separate upper and lower bodies; remove "O" ring.

8. Hold element up to light and inspect tubes (Donaclone type) for dust deposits. Remove dust with stiff fiber brush.

9. Inspect gaskets and "O" rings; discard if worn or mutilated.

10. Inspect element, after cleaning, to be sure no holes are present.

11. Position upper body with gasket on lower body; secure with retainer clamp.

12. Install element and inner cover in position.

13. Be sure gasket washer (4, Fig. 5-12) is in place under wingnut before tightening.

14. Install cover.

15. Install dust cup.

Replace Cartridge-Type Air Cleaner Element

Perform at AC Check under adverse conditions

Two Stage

Disassembly

1. Loosen wing nuts (4, Fig. 5-14) on air cleaner housing (5) to remove pre-cleaner panel with dust bin (1). To remove pre-cleaner panel equipped with exhaust aspirator (2) loosen "U" bolt clamp securing pre-cleaner to aspirator tubing.

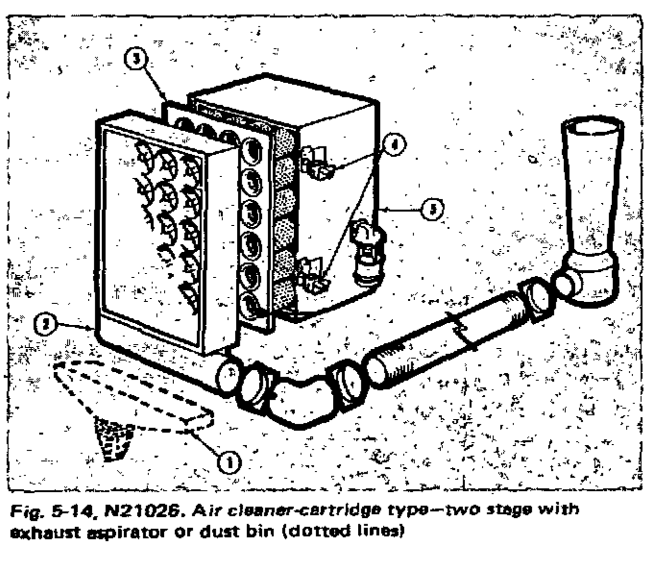


Fig. 5-14, N21026. Air cleaner-cartridge type—two stage with exhaust aspirator or dust bin (dotted lines)

2. To remove dirty Pamic cartridge (3), insert fingers in cartridge opening using a "bowling-ball grip". Loosen all four corners of cartridge, one at a time, by pulling straight out.

   With larger cartridge, it may be necessary to break seal along edges of cartridge. After seal has been broken, pull the cartridge straight out and slightly up so cartridge will clean sealing frame and edges of air cleaner housing.

Cleaning And Inspection

1. Clean pre-cleaner openings of all soot, oil film and any other objects that may have become lodged in openings.

a. Remove any dust or dirt that may be in lower portion of pre-cleaner and aspirator tubing. Inspect inside of air cleaner housing to be sure it is free of all foreign material.

b. Pre-cleaners with dump valve in dust bin automatically expell dust and water while engine is running. During engine operation the dust bin is under a slight vacuum utilizing the engines pulsing action to open and close the dump valve. The dump valve also expells dirt and water whenever engine is shut down.

2. Inspect dirty cartridge for soot or oil. If there is soot inside Pamic tubes, check for leaks in engine exhaust system, exhaust "blow back" into air intake and exhaust from other equipment. If cartridge appears "oily", check for fumes escaping from crankcase breather. Excessive oil mist shortens life of any dry-type cartridge. Trouble-shooting before new cartridge is placed in the air cleaner can appreciably lengthen cartridge life.

3. It is not recommended to clean and reuse cartridge. Considerable laboratory testing shows that shaking, washing, rapping or blowing out with compressed air can cause cracks or ruptures in paper filter cartridges, which would permit wear-causing dirt particles to enter engine. If a failure occurs, there is no way of discovering it until cartridge is changed again.

4. Repeated tests have also shown that fine particles that penetrate deep into pores of filter paper cannot be removed by any method of cleaning. When returned to service, life expectancy (even if no failure occurs) of a paper cartridge will be only a fraction of original service life.

5. Inspect clamps and flexible hose or tubing to be sure all fittings are air tight on cleaners with exhaust aspirators.

6. The pre-cleaner dust bin is self-cleaning.

Assembly

1. Inspect new filter cartridge for shipping damage before installing.

2. To install a new cartridge, hold cartridge (3; Fig. 5-14) in

same manner as when removing from housing (5). Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaning housing.

3. The cleaner requires no separate gaskets for seals, therefore, care must be taken when inserting cartridge to insure a proper seat within air cleaner housing. Firmly press edges and corners of cartridge with fingers to effect a positive air seal against sealing flange of housing. Under no circumstances should cartridge be pounded or pressed in center to effect a seal.

4. Replace pre-cleaner panel (2) and tighten wing nuts (4). On pre-cleaner with exhaust aspirator, assembled aspirator tube to pre-cleaner panel and tighten "U" bolt.

5. Care should be taken to keep leaves, rags or side curtains from obstructing cleaner face. Obstructing air intake can result in reverse exhaust flow through bleed line and damage to cartridge.

Single Stage

Disassembly

1. Loosen wing nuts (3, Fig. 5-15) on air cleaner housing and remove moisture eliminator (1) and rain guard, if used.

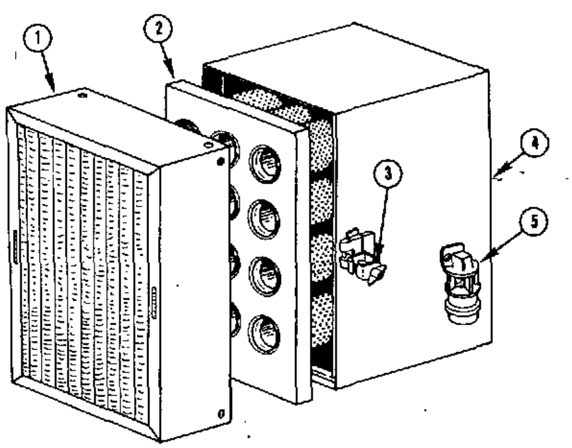


Fig. 5-15, V11009. Cartridge - type air cleaner - single stage

2. To remove dirty Pamic cartridge (2), insert fingers in cartridge opening using a "bowling-ball grip". Loosen all four corners of cartridge, one at a time, by pulling straight out. With larger cartridge, it may be necessary to break seal along edges of cartridge. After seal has been broken, pull the cartridge straight out and slightly up so cartridge will clear sealing frame and edges of air cleaner housing.

Cleaning And Inspection

1. Wash moisture eliminator in an approved solvent and dry thoroughly.

2. Wipe out air cleaner housing with a clean cloth.

3. Inspect housing and moisture eliminator for dents, split seams and holes; repair or replace as necessary.

4. Inspect hose, tubing and clamps for damage; replace if defective.

Assembly

1. Inspect new filter cartridge for shipping or handling damage before installing.

2. To install a new cartridge, hold cartridge (2, Fig. 5-15) in same manner as when removing from housing (4). Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.

3. The cleaner requires no separate gaskets for seals; therefore, care must be taken when inserting cartridge to insure a proper seat within air cleaner housing. Firmly press all edges and corners of cartridge with fingers to effect a positive air seal against sealing flange of housing. Under no circumstances should cartridge be pounded or pressed in center to effect a seal.

4. Position moisture eliminator (1) to air cleaner housing (4) and secure wing nuts (3).

Clean (Externally) Radiator Core

Perform at "AC" Check under extremely dusty conditions.

Blow out all insects, dust, dirt and debris (leaves, bits of paper, etc.) that may be on front of radiator or lodged between radiator core fins and tubes.

Change Oil Bath Air Cleaner Oil

Perform at "AC" Check under extremely dusty conditions.

Before dirt build-up reaches 1/2 in. [12.700 mm] remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Fill oil cup to level indicated by bead on its side with clean, fresh oil of the same grade as that in crankcase and assemble to cleaner. In extremely cold weather a lighter grade oil may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in oil bath air cleaners.

Caution: Never use crankcase drainings.

Clean Oil Bath Cleaner Tray Screen

1. Remove tray screen (1, Fig. 5-16) from air cleaner body by a twisting or turning motion.

2. Immerse tray screen in kerosene or cleaning solvent.

3. Slosh screen up and down several times. Dry thoroughly with compressed air, and reassemble to air cleaner.

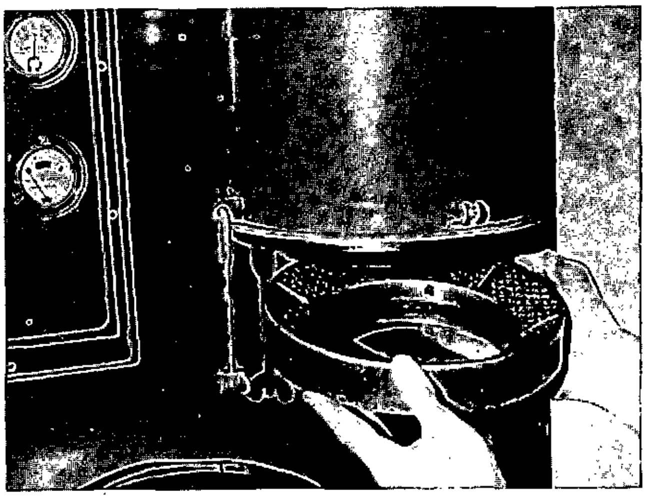


Fig. 5-16, N11002. Removing air cleaner tray screen

Note: If tray screen is extremely dirty or coated with varnish, it may be necessary to singe the screen with a flame. Be careful not to melt tin plate on screen.

4. Install tray screen to air cleaner body by reversing the removal procedure.

Change Crankcase Breather

Perform at "AC" Check under extremely dusty conditions.

Inspect dry-type crankcase breathers at each B Check or at each oil change interval. If breather element is not dirty or oil soaked, element change may be extended to next oil change.

Dry-type crankcase breathers containing a chemically treated paper element are used on naturally aspirated engines. Install new element – **Do Not Attempt To Clean.** Fig. 5-17.

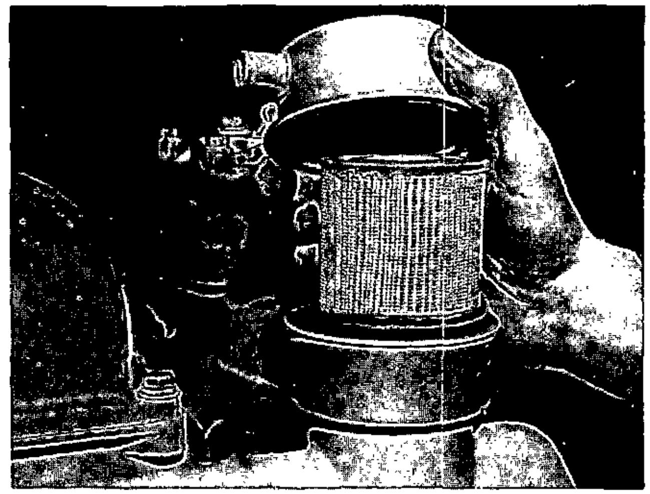


Fig. 5-17, V11923. Changing crankcase breather - paper element

Check Air And Vapor Line Connections

Perform at "AC" Check under extremely dusty conditions.

Check all air and vapor lines and connections from compressor, rocker housing covers and cylinder heads for leaks, breaks, stripped threads, etc.; correct as needed.

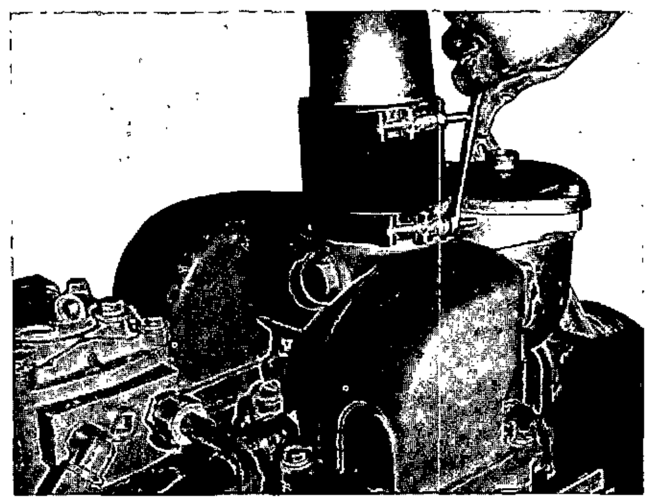


Fig. 5-18, V11922. Check air intake piping

In cold weather, condensed moisture in air tanks and lines may freeze and make brakes or cranking motors useless.

Drain air tanks to keep all water out of brake system.

Check Air Piping

Perform at "AC" Check under extremely dusty conditions.

Check air intake piping from air cleaner to intake manifold. Fig. 5-18. Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsing hose, or other damage. Tighten clamp nuts to 5 to 16 in. lb. [0.0575 to 0.1840 kg m]; replace parts as necessary to insure an airtight air intake system. Make sure that all air goes through air cleaner.

Check Throttle Linkage

Check throttle linkage and make sure it is in good operating condition. Check throttle travel to make sure linkage operates throttle from stop to full throttle and degrees of travel are within specifications for application.

Check Fuel Pump Seals

Throttle stop screws and governor idle screw plug are "sealed" after final fuel pump setting or adjustment. Seals should be regularly checked to prevent, or catch immediately, unauthorized fuel pump settings.

Change Corrosion Resistor

On new or newly rebuilt engines, change corrosion resistor element first 100 hours or 3000 miles and thereafter, change corrosion resistor element at each "B" check unless facilities are available for testing. See "Check Engine Coolant", following. Change element when concentration drops below 100 grains per gal [3.785 lit or 0.83267 UK gal].

Selection of element to be used should be based upon "Coolant Specifications", Section 3.

Note: Whenever a cooling system is changed from one element formula to the other, the system must be drained and flushed.

Caution: Make sure corrosion resistor, bracket and mounting point on engine are free from paint to form a good ground. If located off engine, run ground wire from resistor mounting capscrew to engine.

To Change Element:

1. Close shut-off valves on inlet and drain lines. Unscrew drain plug at bottom of housing.
2. Remove cover capscrews and cover. Fig. 5-19.
3. Remove plate securing element; lift element(s) from housing and discard. Remove plate below element.
4. Lift spring from housing.
5. Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.
6. Replace spring and lower magnesium plate.
7. Remove new element from transparent bag; install element in housing.
8. Replace upper aluminum plate, gasket and cover; secure with capscrews and washers.
9. Replace drain plug and open shut-off valves in inlet and drain lines.

Check Engine Coolant

Periodic tests of engine coolant should be made to insure the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for specific condition of operation. In cases where "make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary.

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating with chromate compounds, the concentration of effective inhibitor dissolved in coolant can be measured by the color comparison method. Cummins Coolant Checking Kit

Fig. 5-19, V11919. Changing Cummins corrosion resistor

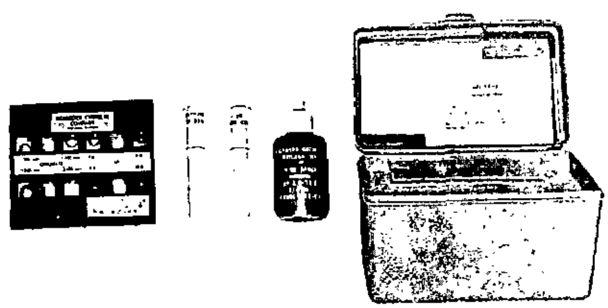


Fig. 5-20, N11946. ST-993 Coolant Checking Kit

ST-993 is available from Cummins Distributors for this check. Fig. 5-20.

Most commercially available antifreezes contain a coloring dye that renders the color comparison method ineffective. When colored antifreezes are present in the coolant, effective control of corrosion can be determined by inspecting coolant for accumulation of reddish-brown or black finely granulated dirt. A small amount of corrosion *produces significant quantities of these corrosion products;* therefore, if corrosion resistor servicing is adjusted at the first indication of increased accumulation of these products, actual corrosion will be limited to a negligible amount.

Examine sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from bottom of radiator after allowing coolant to settle.

Note: Use of chromate compound, added to the coolant without a corrosion resistor, with antifreeze is not recommended.

pH Value Test:

1. Separate tubes marked "pH" are furnished in the test kit. Select a tube and fill to mark with coolant to be checked.
2. Add eight drops of pH Reagent to tube and mix thoroughly.
3. Insert tube in comparator hole marked "pH".
4. Compare color of test sample with color standards on either side. Preferred range is 8.3 to 9.5.
5. Wash out test tubes after each test and keep reagent container caps in place.

Chromate Concentration Test:

1. Draw sample of coolant and pour into tube marked "chromate".
2. Dilute coolant 50% with clear water.
3. Insert sample into comparator hole marked "chromate".
4. Compare color of test sample with color standards on either side. Preferred range is 100 to 150 grains per gal [3.785 lit or 0.83267 UK gal] or 1700 to 2500 parts per million (ppm). The dilution (step 2) is done to match the standards, but results are 3400 to 5000 ppm range of engine coolant.
5. Wash out test tubes after each test.

Adjusting Coolant To Specifications

If above tests indicate coolant is outside specifications, make an adjustment immediately to prevent corrosion.

If Cummins Corrosion Resistor is used change element and run engine four to six hours; then, check coolant again; in extreme cases it may be necessary to change element a second time. However, the latter condition may be due to larger coolant system than corrosion resistor was designed to treat; note reference on resistor label.

If chromate compounds are used, add enough compound to bring concentration to proper level. Normal usage is 1/2 oz. [218.75 grains] chromate for each 1 gal [3.785 lit or 0.83267 UK gal] of coolant.

Table 5-3: Comparison Units Chromate Concentration

Ounces Per Gallon	Parts Per Million	Grains Per Gallon
0.16	850	50
0.32	1700	100
0.50	2550	150

C—Maintenance Checks

At each "C" maintenance check, first perform all "A" "AC" and "B" checks in addition to those following.

Steam Clean Engine

There are many reasons why exterior of engine should be kept clean. Dirt from the outside will find its way into fuel and lubricating oil filter cases and into rocker housings when covers are removed unless dirt is removed first.

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use mineral spirits or some other solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the steam jet.

Check Manifold Capscrews

Check air intake manifolds mounting hardware for tightness; correct deficiencies as required.

Lubricate Water Pump And Fan Hub

1. The water pump and fan hub contain grease fittings, or pipe plugs which must be removed and a grease fitting installed, to apply grease.
2. Remove pipe plug(s) from fan hub and water pump, install grease fitting and lubricate; give one "shot" (approx. 1 tablespoon) each "C" check. Figs. 5-21 and 5-22. After fan hub is lubricated, remove grease fitting and install both pipe plugs removed.

Check And Adjust Belt Tension

The service life of belts used to drive fans, water pumps and alternators can be greatly extended by proper installation, adjustment and maintenance practices. Neglect or improper procedures often lead to problems of cooling or bearing failures, as well as short belt life. Following are the most important rules to be observed to extend belt life.

Installation

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.

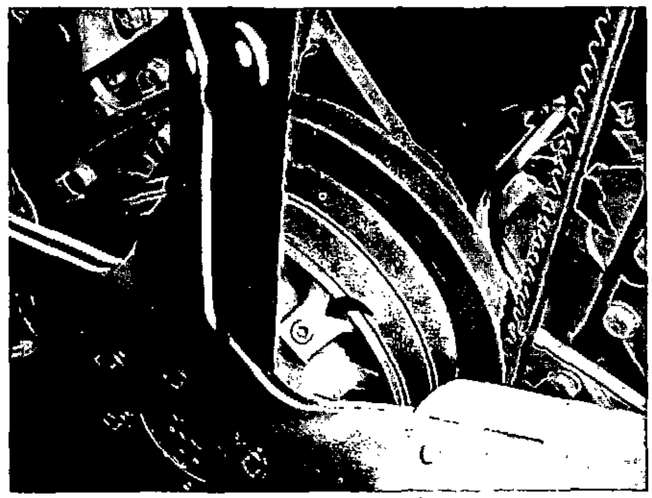


Fig. 5-21, V11906. Fan hub lubrication point

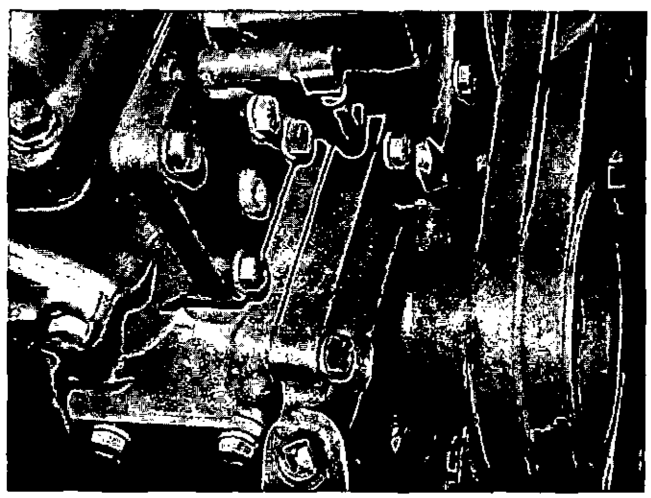


Fig. 5-22, V11907. Water pump lubrication point

2. Always replace belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth should not vary over 1/16 in. [1.587 mm] on matched belt sets.
3. Pulley misalignment must not exceed 1/16 in. [1.587 mm] for each ft [0.3048 m] of distance between pulley centers.

4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 in. [2.381 mm] above top edge of groove.

5. Do not allow belts to rub any adjacent parts.

Belt Tension

1. Tighten belts until a reading of 90 to 110 lb. is indicated on ST-968 Belt Tension Gauge, Fig. 5-23, or ST-1138 (if belt is over 1/2 in. [12.700 mm] wide).

2. If belt tension gauge is not available, tighten belts so pressure of index finger will depress belt as shown in Table 5-4. The index finger should be extended straight out from hand; in this manner, force will be approximately 13 lb. [5.8968 kg] deflection per ft. [0.3048 m] of span (2).

3. Deflection (1, Fig. 5-24) should equal amount indicated in Table 5-4 for each foot of belt span (2).

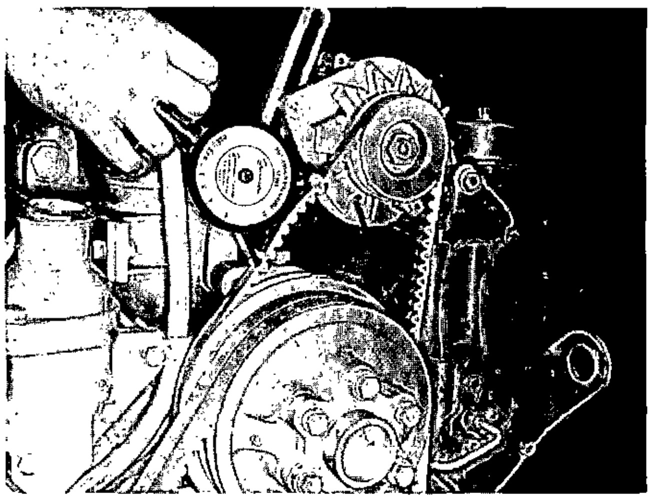


Fig. 5-23, V11918. Checking belt tension with ST-968

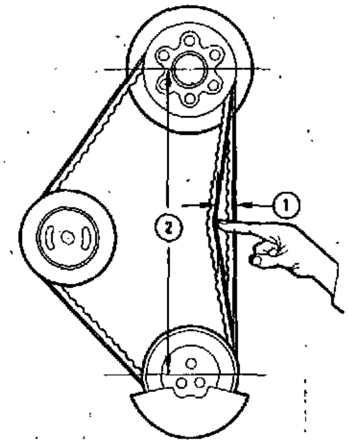


Fig. 5-24, V10809. Checking belt tension manually.

Table 5-4: Belt Tension – In. [mm]

Belt Width	Deflection Per Ft. [0.3048] of Span
1/2 [12.700]	13/32 [10.318]
11/16 [17.462]	13/32 [10.318]
3/4 [19.050]	7/16 [11.112]
7/8 [22.225]	1/2 [12.700]
1 [25.400]	9/16 [14.287]

Readjusting New Belts

All new belts will loosen after running for an hour or more and must be readjusted. Readjust as described under "Belt Tension".

Belt Care Or Maintenance

Do not tighten belt beyond figures given to eliminate belt squeak. Squeak does not necessarily mena belt slippage. Tightening to excess may damage bearings as well as belts.

Clean Fuel Pump Screen And Magnet

PT Fuel Pump

Remove and clean fuel pump filter screen at each "C" check. To clean filter screen:

1. Loosen and remove cap at top of fuel pump. Remove spring. Lift out filter screen assembly. Fig. 5-25.

2. Remove top screen retainer from filter screen assembly.

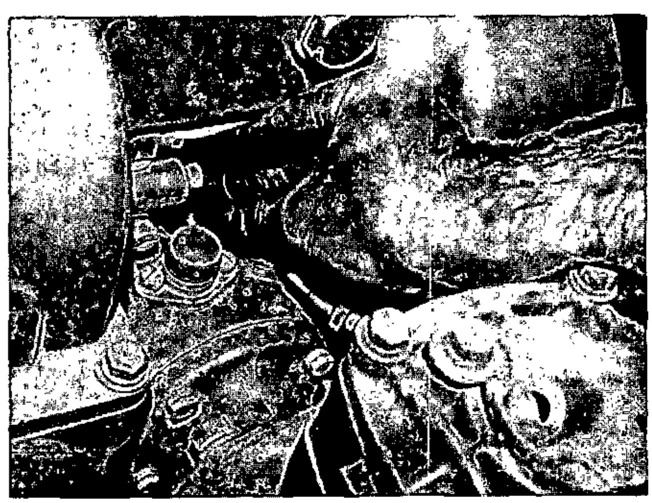


Fig. 5-25, V11911. Replacing fuel pump filter screen

3. Clean screen and magnet in cleaning solvent and dry with compressed air.

4. Replace screen retainer and install filter screen assembly in fuel pump with hole down. Replace spring on top of filter screen assembly.

5. Replace cap; tighten to 20/25 ft-lb [2.7660/3.4575 kg m].

Fuel Pump With MVS Governor

1. Remove filter cap and dynaseal from governor housing.

2. Remove "O" ring retainer, "O" ring, screen and spring from filter cap.

3. Using a screwdriver or wire hook, remove bottom screen and magnet assembly from fuel pump housing. Remove screen retainer.

4. Clean parts as described above.

5. Install screen retainer and place bottom screen assembly in fuel pump housing with removable end up.

6. Install spring, large coil first, in filter cap; install upper screen, closed end first, in cap and snug against spring.

7. Install new "O" ring on "O" ring retainer; insert in filter cap, "O" ring first.

8. Install filter cap and dynaseal in governor housing; tighten cap to 20/25 ft-lb [2.7660/3.4575 kg m] with torque wrench and screwdriver adapter.

Adjust Injectors And Valves

Injectors and valves must be in correct adjustment at all times for engine to operate properly. This controls engine breathing and fuel delivery to cylinders. Final adjustment must be made when engine is at operating temperature. Injectors must always be adjusted before valves. The procedure is as follows:

Note: Always retorque injector hold down clamp capscrews to 30/35 ft-lb [4.1490/4.8405 kg m] before adjusting injectors.

Valve Set Mark Alignment

1. Turn crankshaft in direction of rotation until No. 1 VS mark appears on the vibration damper or crankshaft pulley. See Fig. 5-26 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1; if not, advance crankshaft one revolution. See Fig. 5-27, Fig. 5-28 and Table 5-5 for firing order.

Note: Do not use fan to rotate engine.

2. Adjust injector plunger, then crossheads and valves of first

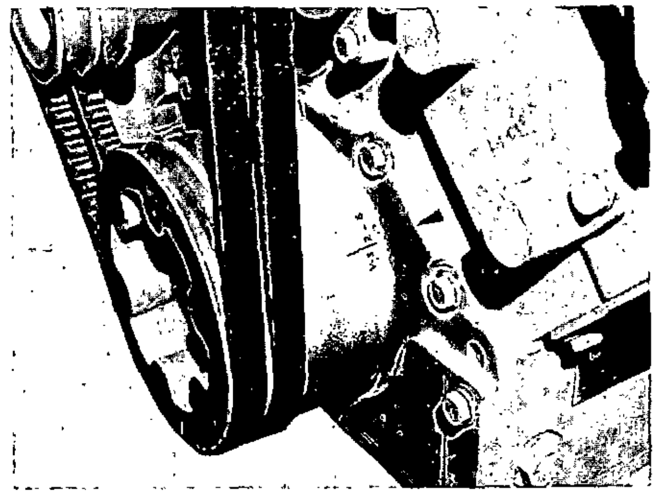


Fig. 5-26, V11913. Valve set marks

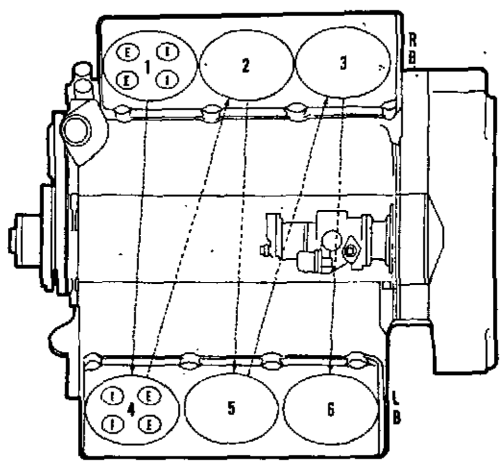


Fig. 5-27, V11461. V6 Firing order diagram

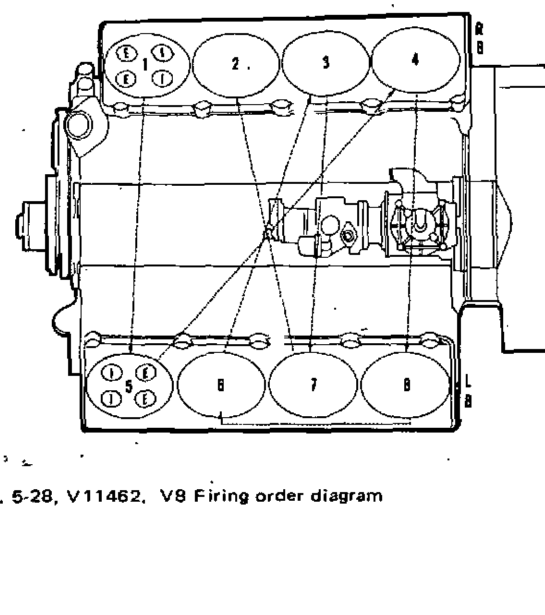


Fig. 5-28, V11462. V8 Firing order diagram cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to next VS mark corresponding to firing order of engine and corresponding cylinder will be ready for adjustment. See Table 5-5.

3. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

Table 5-5: Engine Firing Order

Right Hand	V8	1-5-4-8-6-3-7-2
Right Hand	V6	1-4-2-5-3-6

Note: Two complete revolutions of crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.

Injector Plunger Adjustment

Before adjusting injector, tighten injector hold-down capscrew to 30/35 ft-lb [4.1490/4.8405 kg m].

The injector plungers of all engines must be adjusted with an in.-lb torque wrench to a definite torque setting. Snap-On Model TQ12B or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 5-29.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

2. Loosen adjusting screw one turn; using a torque wrench calibrated in in.-lb and a screwdriver adapter, tighten the adjusting screw to values shown in Table 5-6 for cold setting and tighten the locknut.

Note: After all injectors and valves are adjusted and engine has been started and warmed up to 140 deg. F [60.0 deg. C] oil temperature, reset injectors to the warm setting. This is only necessary if injectors, lever assemblies or push rods have been changed.

3. Hold injector adjusting screw and tighten injector adjusting screw locknut to values indicated in Table 5-7. When ST-669 Adapter is used, nut torque is reduced to compensate for additional torque arm length. Fig. 5-30.

Table 5-6: Injector Plunger Adjustment Torque

Oil Temperature 70 deg. F [21.1 deg. C]	Oil Temperature 140 deg. F [60 deg. C]
60 in. lb. [0.6900 kg m]	60 in. lb. [0.6900 kg m]

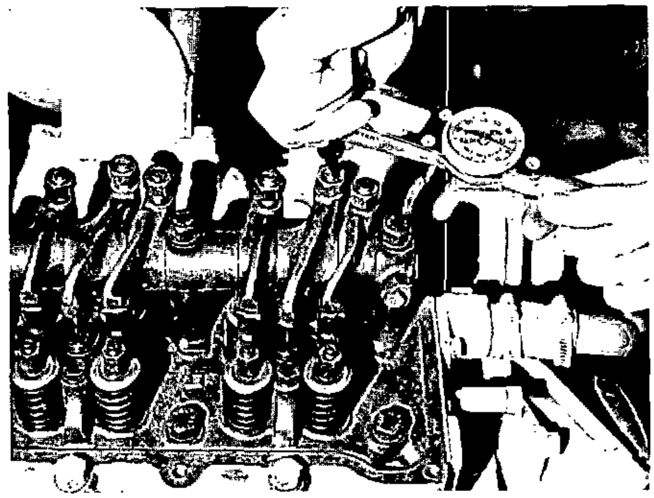


Fig. 5-29, V11914. Adjusting injector plungers

Table 5-7: Injector And Valve Locknut Torque

With ST-669	Without ST-669
30/35 ft-lb [4.1490/4.8405 kg m]	40/45 ft-lb [5.5320/6.2235 kg m]

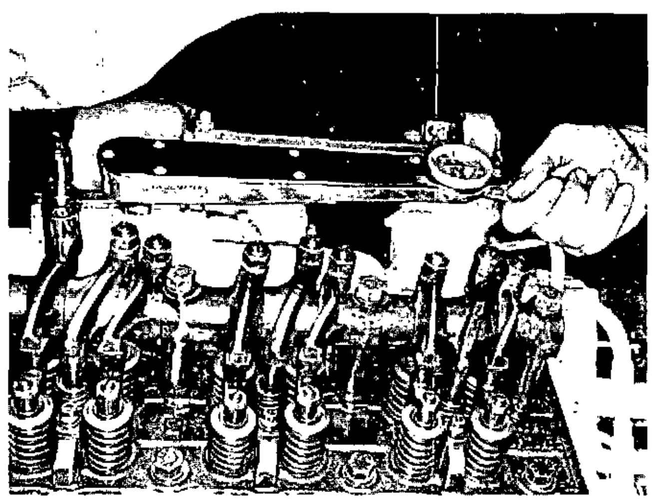


Fig. 5-30, V114115. Tightening adjusting screw locknut

Crosshead Adjustments

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.

2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).

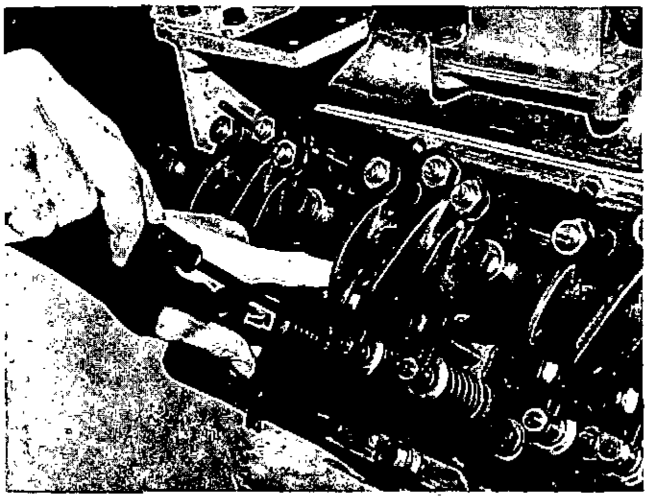


Fig. 5-31, V11915. Adjusting crossheads

3. Turn down crosshead adjusting screw until it touches valve stem. Fig. 5-31.

4. Hold adjusting screw in this position and torque locknut to 25/35 ft-lb [3.4575/4.1490 kg m].

Note: Insure that crosshead retainers on exhaust valves (if used) are positioned on crossheads and valve springs properly. Crosshead guide tang must seat with equal clearance on either side of the valve spring retainer.

5. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.050 in. [1.2700 mm] clearance at this point.

Valve Adjustment

The same crankshaft position used in adjusting injectors is used for setting intake and exhaust valves.

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Valve clearances are shown in Table 5-8. Turn screw down until lever just touches gauge and lock adjusting screw in this position with locknut. Fig. 5-32. Torque locknut to values indicated in Table 5-7; note Step 3 under "Injector Plunger Adjustment".

Table 5-8: Valve Clearance – In. [mm]

Intake Valves		Exhaust Valves	
Oil Temperature		Oil Temperature	
70 deg. F [21.1 deg. C]	140 deg. F [60 deg. C]	70 deg. F [21.1 deg. C]	140 deg. F [60 deg. C]
0.012 [0.3048]	0.010 [0.2540]	0.022 [0.5588]	0.020 [0.5080]

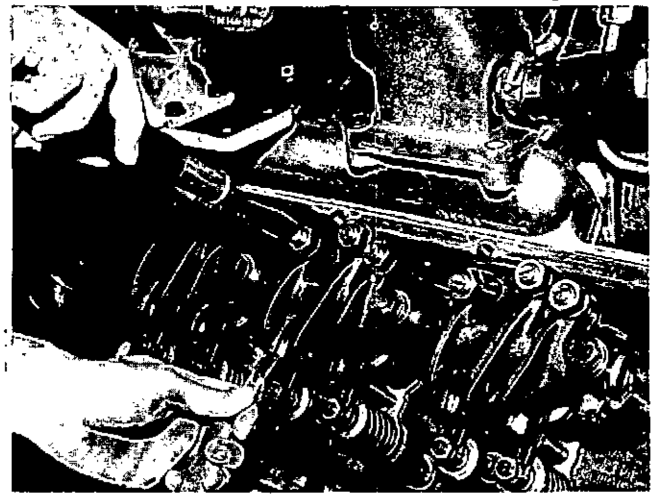


Fig. 5-32, V11916. Adjusting valves

2. Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature.

Check Fuel Manifold Pressure

1. Check maximum fuel manifold pressure with ST-435 Pressure Gauge. Fig. 5-33. Remove plug from shut-down valve on fuel pump and connect gauge line. Run engine up until governor "cuts in" and check maximum pressure reached. Compare with previous readings to determine if fuel pressure output is satisfactory. Normally this check is required only if loss of power is suspected.

2. Always make above checks on a hot engine and operate engine for a minimum of five minutes between checks to clear system of air.

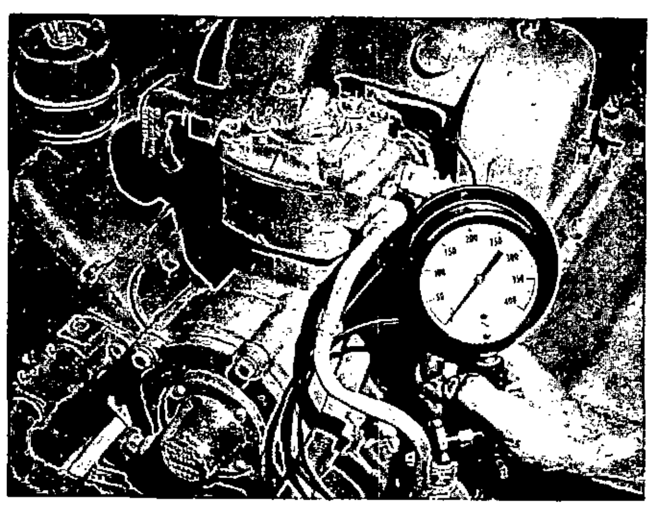


Fig. 5-33, V11917. Checking fuel manifold pressure

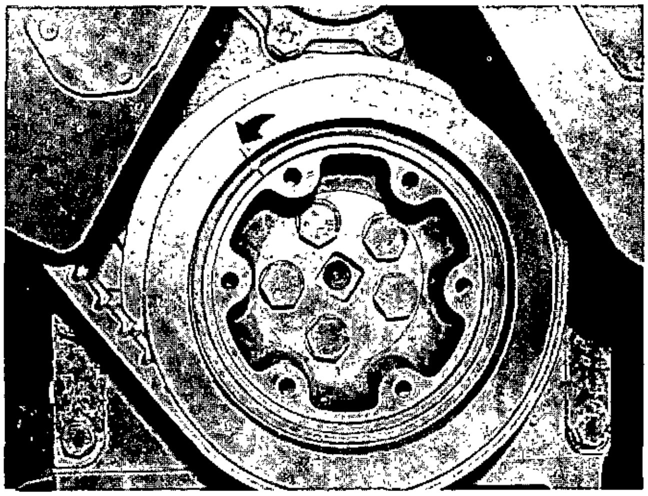


Fig. 5-34, V11928. Vibration damper alignment marks

Note: Injectors must be adjusted properly before checking fuel manifold pressure. See Page 5-21.

Check Vibration Damper Alignment

Vibration damper hub and inertia member are stamped with an index mark to permit detection of movement between the two components. Fig. 5-34. There should be no relative rotation between hub and inertia member resulting from engine operation.

Check for extrusion of rubber particles between hub and inertia member.

Clean Oil Bath Air Cleaner

Steam Cleaning

Steam clean oil-bath air cleaner main body screens. Direct steam jet from air outlet side of cleaner to wash dirt out in opposite direction of air flow.

Solvent Bath Cleaning

This method of cleaning requires a 55 gal [219.175 lit] drum and a source of air pressure. Any good commercial solvent may be used.

1. Steam clean exterior of cleaner.
2. Remove air cleaner oil cup.
3. Clamp hose with air line adapter to air cleaner outlet.
4. Submerge air cleaner in solvent.
5. Introduce air into unit at 3/5 psi [0.21093/0.35155 kg/sq cm] and leave in washer 10 to 20 minutes.
6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent.
7. Dry thoroughly with compressed air.

   Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from cleaner.

8. If air cleaner is to be stored, dip in lubricating oil to prevent rusting of screens.

Note: If screens cannot be thoroughly cleaned by either method, or if body is pierced or otherwise damaged, replace with new air cleaner.

Check Alternator And Cranking Motor

Failure of an alternator or cranking motor may cause unit downtime and nearly always results in expensive replacement.

Dust and dirt, if allowed to accumulate in alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.

Remove cover band, if used, and blow out dust and dirt with compressed air. Fig. 5-35.

1. Inspect terminals for corrosion and loose connections and wiring for frayed insulation. Check mounting bolts for tightness and check belt for alignment, proper tension and wear.
2. Slip rings and brushes can be inspected through alternator end frame assembly. If slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean slip rings. Hold polishing cloth against slip rings with alternator in operation and blow away all dust after cleaning operation. Fig. 5-35.

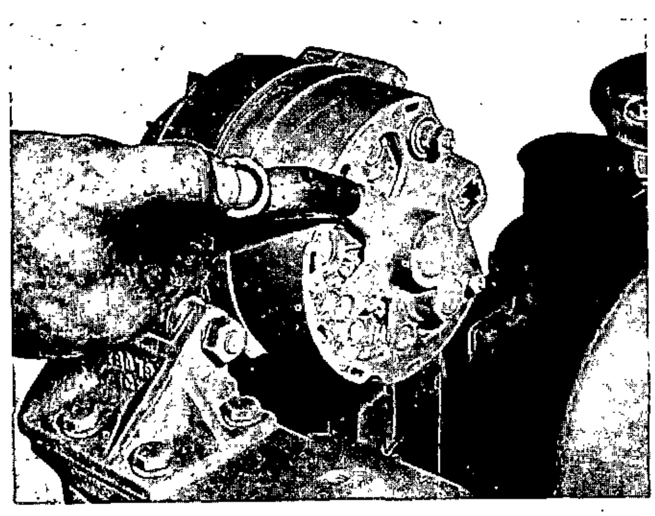


Fig. 5-35, V11925. Blowing dust from alternator

3. Check alternator bearings for wear. Shaft will be excessively loose if bearings are worn.

4. If brushes are worn close to the holder, the alternator must be removed and sent to manufacturer's rebuild station.

Air Compressor Unloader Valve

1. Remove air line at air compressor unloader valve.

2. Remove capscrews and washers securing unloader valve to air compressor.

3. Screw a 4 in. [101.6 mm] piece of pipe in inlet boss and "work" unloader valve assembly gently from air compressor cylinder head.

4. Inspect unloader valve for carbon deposits etc.

5. Clean thoroughly in approved cleaning solvent; dry with compressed air.

6. Apply clean lubricating oil to body and "O" ring; install cap over spring in compressor cylinder head.

   Note: Be sure three legs of cap protrude into three openings of intake valve seat.

7. Install flatwashers, lockwashers and capscrews. Torque alternately to 8/10 ft.-lb.

8. Install air line as removed in step 1 above.

D–Maintenance Checks

At each "D" maintenance check, perform all "A", "AC", "B" and "C" checks in addition to those following.

Check Crankshaft-Mounted Fan

Check fan to be sure it is securely mounted. Check fan for wobble or bent blades. Inspect for any relative rotation between hub and inertia member as indicated by index mark, if fan is mounted on vibration damper. Check for extrusion of rubber particles between hub and inertia member.

Bracket-Mounted Fan Hub

Check fan hub and crankshaft drive pulley to be sure that they are securely mounted.

Tighten fan capscrews. Check hub pulley for looseness or wobble and, if necessary, remove fan and hub and tighten the shaft nut. Tighten the bracket capscrews.

Tighten Engine Mounting Bolts And Nuts

Engine mounting bolts will occasionally work loose and cause supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Rebuild Water Pump And Fan Hub

Water pump and fan hub rebuild consists of disassembly, cleaning of parts, packing new bearings and parts with proper grease (see Page 3-3) and assembly.

Completely disassemble, clean and inspect at each "D" check. Pack bearings and fill water pump and fan hub bearing cavities 50% to 66% full of multi-purpose industrial grease meeting specifications shown on Page 3-3. Cummins Distributors have rebuilt assemblies available so down time is reduced to a minimum.

Clean And Calibrate Injectors

Clean and calibrate injectors as required to prevent restriction of fuel delivery to combustion chambers. Frequency of cleaning and smoke is reduced substantially by keeping injectors well adjusted. Because of special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

If you are equipped to clean and calibrate injectors, refer to Bulletin No. 983536 or 983532.

Check Fuel Pump Calibration

Check fuel pump calibration on engine as required. See the nearest Cummins distributor or dealer for values.

E–Maintenance Checks

At each "E" maintenance check, perform all "A", "AC", "B", "C", and "D" checks in addition to those following.

The "E" maintenance check is often referred to as a chassis overhaul, where engine is not removed from the unit but some assemblies are rebuilt. In addition, a major inspection should be performed to determine whether engine may be operated for another service period, or whether it should be completely overhauled. Oil consumption, oil pressure at idling, dilution and other signs of wear should be annalyzed as part of the inspection.

Since major inspection requires partial disassembly of engine, it should be done only in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and with disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

At this period, perform all previous checks and:

Rebuild Cylinder Head
Rebuild Lubricating Oil Pump
Rebuild Air Compressor
Rebuild Injectors
Replace Front and Rear Crankshaft Seals
Inspect Cylinder Liners
Replace Cylinder Liner Seals
Inspect Pistons
Inspect Crankshaft Journals
Install New Piston Rings
Inspect and Replace, as necessary, Main and Connecting Rod Bearings
Clean Oil Cooler
Rebuild Fuel Pump
Replace Vibration Damper

Parts which are worn beyond worn replacement limits at this inspection should be replaced with new or rebuilt parts or units.

If, during major inspection, it is determined crankshaft journals or any other engine parts are worn beyond worn replacement limits, engine should be removed and completely rebuilt.

Other Maintenance Checks

There are some checks on engine which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Check Shutterstats And Thermatic Fans (As Needed)

Shutterstats and thermatic fans must be set to operate according to range of thermostat with which they are used. Table 5-9 gives settings for shutterstats and thermatic fans as normally used. The 180/195 deg. F [82.2/90.6 deg. C] thermostats are used only with shutterstats that are set to close at 187 deg. F [86.1 deg. C] and open at 195 deg. F [90.6 deg. C].

Clean Cooling System (Spring And Fall)

The cooling system must be clean to do its work properly.

Scale in the system slows down heat absorption from water jackets and heat rejection from radiator. Use clean water that will not clog any of the hundreds of small passages in radiator or water passages in cylinder block. Clean radiator cores, heater cores, oil cooler and cylinder block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

The best way to insure an efficient cooling system is to prevent formation of rust and scale by using a Cummins Corrosion Resistor, but if they have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by neutralizer and flushing.

Pressure Flushing

Flush radiator and block when anti-freeze is added or removed, or before installing a Corrosion Resistor on a used engine.

When pressure flushing radiator, open upper and lower hose connections and screw radiator cap on tight. Use hose connections on both upper and lower connections to make the operation easier. Attach flushing gun nozzle to lower hose connection and let water run until radiator is full. When full, apply air pressure gradually to avoid damage to the core. Shut off air and allow radiator to refill; then apply air pressure. Repeat until water coming from radiator is clean.

Sediment and dirt settle into pockets in block as well as radiator core. Remove thermostats from housing and flush block with water. Partially restrict lower opening until cylinder block fills. Apply air pressure and force water from lower opening. Repeat process until stream of water coming from block is clean.

Check Hose (Spring And Fall)

Inspect by-pass filter and cooling system hose and hose connections for leaks and/or deterioration. Particles of deteriorated hose can be carried through cooling system or lubricating system and restrict or clog small passages, especially radiator core, and lubricating oil cooler, and slow down or partially stop circulation. Replace as necessary.

Check Thermostat (Fall)

Most Cummins Engines are equipped with either medium 170/185 deg. F [76.7/85.0 deg. C] or low 160/175 deg. F [71.1/79.4 deg. C] and in a few cases high-range 180/195 deg. F [82.2/90.6 deg. C] thermostats, depending on engine application.

The lower value indicates where thermostat starts to open and the higher value where it is fully open. Check stamping on thermostat; if thermostat does not open and close properly, install same range new thermostat as that removed.

Remove thermostat(s) from thermostat housing(s) and check for proper opening and closing temperatures.

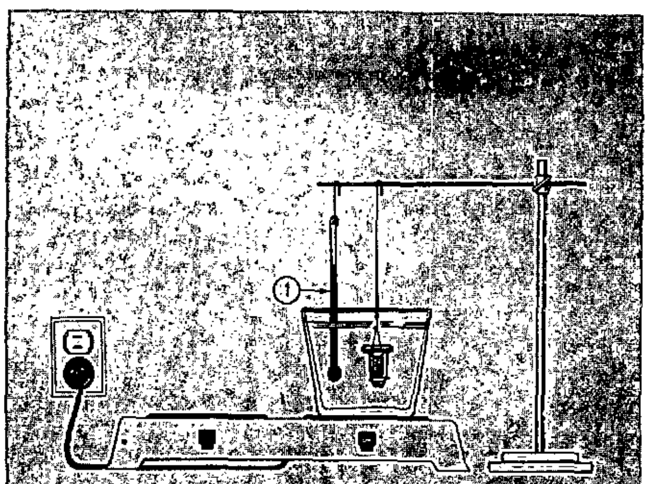


Fig. 5-36, N10809. Testing thermostat

Table 5-9: Thermal Control Settings

Control Used	Setting With 160 deg/175 deg F [71.1 deg/79.4 deg C] Thermostat		Setting With 170 deg/185 deg F [76.7 deg/85.0 deg C] Thermostat		Setting With 180 deg/195 deg F [82.2 deg/90.6 deg C] Thermostat	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185 deg F [85.0 deg C]	170 deg F [76.7 deg C]	190 deg F [87.8 deg C]	182 deg F [83.3 deg C]	Not Used	
Shutterstat	180 deg F [82.2 deg C]	172 deg F [77.8 deg C]	185 deg F [85.0 deg C]	177 deg F [80.6 deg C]	195 deg F [90.6 deg C]	187 deg F [86.1 deg C]
Modulating Fan Lockup	185 deg F [85.0 deg C]		190 deg F [87.8 deg C]		Not Used	
Modulating Shutters Open	175 deg F [79.4 deg C]		185 deg F [85.0 deg C]		195 deg F [90.6 deg C]	

The opening and closing of thermostats can be checked against a thermometer (1, Fig. 5-36) while immersed in water as the water is brought up to temperature by heating.

Check Starting Aid (Fall)

Remove air cleaner or cleaner connection.

Check Starting Fluid Applicator (Fall)

1. Remove starting fluid can; replace if empty.
2. Remove plastic hose from spray nozzle. Clean the hose with compressed air and replace if damaged.
3. Remove spray nozzle from intake corssover connection and inspect orifice holes. Be sure they are clear. Clean with compressed air.

Clean Electrical Connections (Fall)

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork alternator and regulator and shorten their lives.

1. Add water (distilled) to battery cells as required. Check solution level every 15 days during hot weather, every 30 days during cold weather; keep solution filled to 3/8 in. above separator plates.
2. Remove corrosion from around terminals; then coat with petroleum jelly or a non-corrosive inhibitor.
3. Keep connections clean and tight. Prevent wires and lugs from touching each other or any metal except screw terminals to which they are attached.
4. Replace broken or worn wires and their terminals.
5. Have battery tested periodically. Follow battery manufactuer's instructions for maintenance.

Check Crankshaft End Clearance (At Clutch Replacement)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 5-10. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is disassembled for repair, install new thrust rings if wear results in end clearance in excess of 0.022 in. [0.5588 mm].

The check can be made by attaching an indicator to rest against the vibration damper or crankshaft pulley, Fig. 5-37, while prying against the front cover and inner part of pulley or damper. End clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Caution: Do not pry against outer damper ring.

Table 5-10: Crankshaft End Clearance – In. [mm]

New Minimum	New Maximum	Operating Worn Limit
0.004 [0.1016]	0.014 [0.3556]	0.022 [0.5588]

Check Fan Mounting (Spring And Fall)

Check fan to be sure it is securely mounted. Check fan for wobble or bent blades.

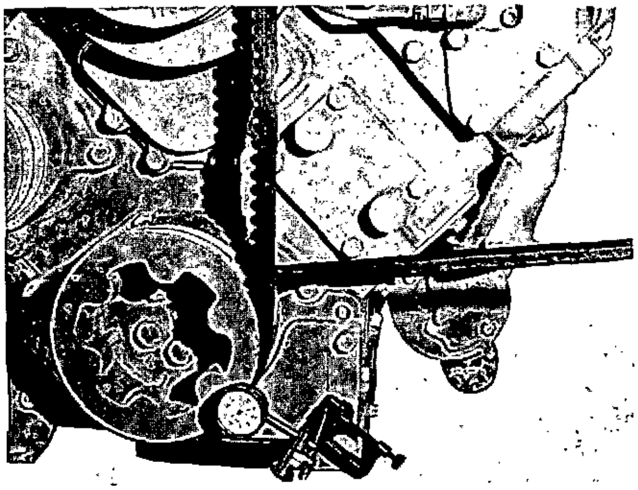


Fig. 5-37, V11927. Checking crankshaft end clearance

Check fan hub and crankshaft drive pulley to be sure that they are securely mounted.

Tighten fan capscrews. Check hub pulley for looseness or wobble and, if necessary, remove fan and hub and tighten the shaft nut. Tighten the bracket capscrews.

Change Converter Oil Filter And Clean Screens (Spring, And Fall)

Change Converter Oil

Oil should be changed every spring and fall in the hydraulic system, or oftener, depending on operating conditions. Also, the oil must be changed whenever it shows traces of dirt or the effects of high operating temperature evidenced by discoloration or strong odor.

Where possible follow converter manufacturer recommendations.

Change Converter Filter And Screen

The hydraulic system filter should be changed every oil change and the strainer screen thoroughly cleaned.

Maintenance Operations Summary Sheet

Information should be collected from each maintenance check sheet and consolidated on a single summary sheet such as shown on the next page. Each engine thus has an established history and cost records can be computed quickly. A review of summary sheet will then tell you which operations can be reduced or increased to make maintenance program more effective, resulting in more efficiency from engine at lower cost. A potential failure caught before it happens provides savings to engine owner and a ready-for-service unit for operator.

MAINTENANCE OPERATIONS SUMMARY

NOTE: INCLUDE SUMMARY OF DAILY "A" REPORTS PERFORMED BETWEEN "B" OPERATIONS IN NEXT "B" REPORT.

ENGINE SERIAL NO.__________

OPERATIONS	CHECKS	DUE	PERFORMED	DATE	MECHANIC	LABOR	PARTS		FUEL	LUBE OIL	TIME LOST	EMERGENCY REPAIRS			REMARKS
	ENTER CHECKS B, C, D, E AS PERFORMED	MILES U.S. GALLONS or HOURS	U.S. GALLONS or HOURS			HOURS	REQ. NO.	COST	U.S. GALLONS	U.S. QUARTS	HRS. OUT OF SERIVICE	LABOR	PARTS	TIME LOST—HOURS	ACCIDENTS—CAUSE OF FAILURE—MAJOR ITEMS REPLACED, ETC.
TOTALS															

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